# Cape Breton Coal Research Laboratory

## Seafloor Topography Over New Phalen Colliery Sydney Coalfield Cape Breton Island, Nova Scotia

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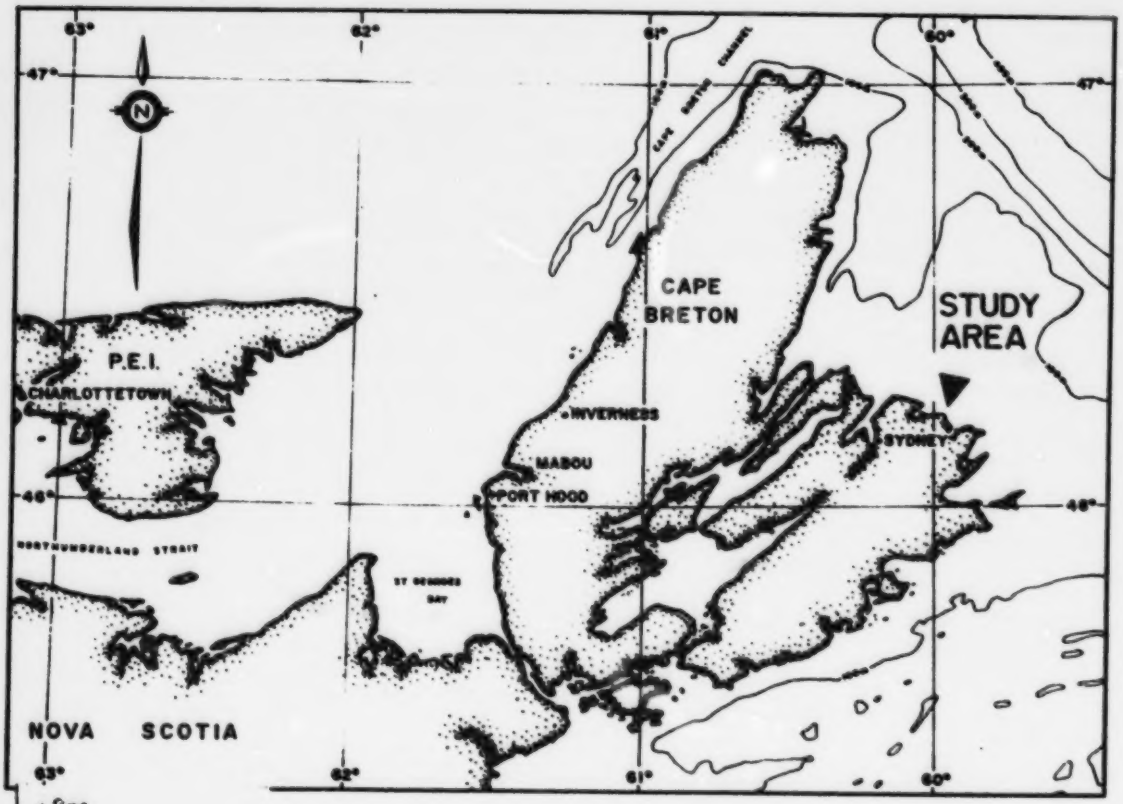
March 1988

## Text and Enclosures




6-8/90
MICROMEDIA

McGregor GeoScience Limited
Dartmouth Nova Scotia Canada

## EXECUTIVE SUMMARY

A 35 line-kilometre grid of marine, high resolution echosounder and subbottom profiler data was acquired over DEVCO's New Phalen Colliery, Cape Breton Island, Nova Scotia. The survey was conducted August 23-29, 1987 for Energy, Mines and Resources (CANMET) and the Cape Breton Coal Research Laboratory. The survey was the first phase of a multi-year program designed to evaluate mining-induced seafloor subsidence by comparing pre-mining seafloor profiles with post-mining seafloor profiles. The principle survey area was above the West Phalen No. 1, No. 2 and No. 3 longwall mine areas.

Using the subbottom profiler data, bedrock was established to occur at the seafloor above most of the western Phalen Colliery workings.

The tracks of survey lines and the echosounder profiles acquired along these tracks were digitized. Using the digital data, individual lines, plan and profile panels were produced. These panels detail the seafloor topography along the pre-mining reference profile lines and display the repeatability of line positions and seafloor profile morphology. Each of the pre-mining panels exist as "AutoCad" drawing files, to which post-mining profiles will be added in future for direct comparison.

It is anticipated that with the recording and display scales employed, subsidence of 0.5 metres or less, will be detectable.

## SOMMAIRE EXECUTIF

Trente-cinq (35) kilomètres de données géophysiques marines et de données d'écho-sondeur à haute résolution ont été acquises dans un quadrillage de tracés au-dessus du site de la Mine de Houille New Phalen, appartenant à DEVCO et située à l'île du Cap Breton, Nouvelle-Ecosse. Ce levé a été mené durant la période du 23 au 29 août, 1987, dans l'intérêt d'Energie, Mines and Ressources, du Centre Canadien de la Technologie des Minéraux et de l'Energie (CANMET) et du Laboratoire de Recherche du Charbon du Cap Breton. Il constitute la première étape d'un programme polyphasé ayant comme but l'évaluation de la subsidence du fond marin induite par les travaux miniers, et ce, par comparison entre profiles du fond marin pré- et post -miniers. La superficie principale de ce levé se trouve au-dessus des sites West Phalen No. 1, No. 2 et No. 3, là où il y a eu des travaux miniers.

Utilisant les données géophysiques, le substratum rocheux a été établi comme survenant au fond marin au-dessus de la plus grande part de l'ouest de la Mine de Houille Phalen.

Le tracé du levé ainsi que les profiles des données de l'écho-sondeur acquis au long de ce tracé ont été numerisés. Utilisant les données numerisées, des panneaux de tracé individuel, de plan et de profil one été produits. Ces panneaux détaillent la topographie du fond marin au long des tracés de profiles de référence pré-miniers et démontrent la répétition de la position des tracés et de la morphologie du profil marin. Chacun de ces panneaux pré-miniers se trouvent dans la forme de fiches illustrées dans le logiciel "AutoCad". Des panneaux de profils post-miniers y seront ajoutés à un moment futur pour comparison directe.

Il est prévu qu'avec les échelles d'enregistrement et de présentation employées, une subsidence de 0.5 mètres ou moins pourrait être perçue.

# DETERMINATION OF SEAFLOOR TOPOGRAPHY OVER THE NEW PHALEN COLLIERY, SYDNEY COALFIELD, CAPE BRETON, NOVA SCOTIA

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McGregor Document Number: P18/363

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## SECTION 1

## INTRODUCTION

A 35 line-kilometer grid of marine high resolution echosounder and subbottom profiler data was acquired over DEVCO's New Phalen Colliery, Cape Breton, Nova Scotia (Figure 1). The survey was conducted August 23-29, 1987 for Energy, Mines and Resources (CANMET) and Cape Breton Coal Research Laboratory with Dr. Tim Aston, the Scientific Authority. The survey was the first phase of a multi-year program designed to evaluate mining-induced seafloor subsidence by comparing pre-mining seafloor profiles with post-mining seafloor profiles. Figure 2 displays the grid of bathymetric and sub-bottom profile lines acquired in 1987 and the location of the existing or planned Phalen mineworkings. Detailed track plots are presented as Enclosures 1 and 2. The principle survey area was above the West Phalen No. 1, No. 2 and No. 3 longwall mine area over which approximately 31 line-km of the data was acquired. The profiles collected in this survey detail the seafloor topography along the pre-mining reference profile lines. Identical lines will be run after longwall mine advancement. Changes in the seafloor topography pre- and post-mining will provide a measure of mining-induced, seafloor subsidence.

This report describes the data collected, their accuracy and the methodology used to process and analyse it. The field work aspect of this project is described in reports operations, survey systems, personnel and navigation included as Appendices 1 through 4 respectively. A data inventory and quality summary is given in Appendix 5.

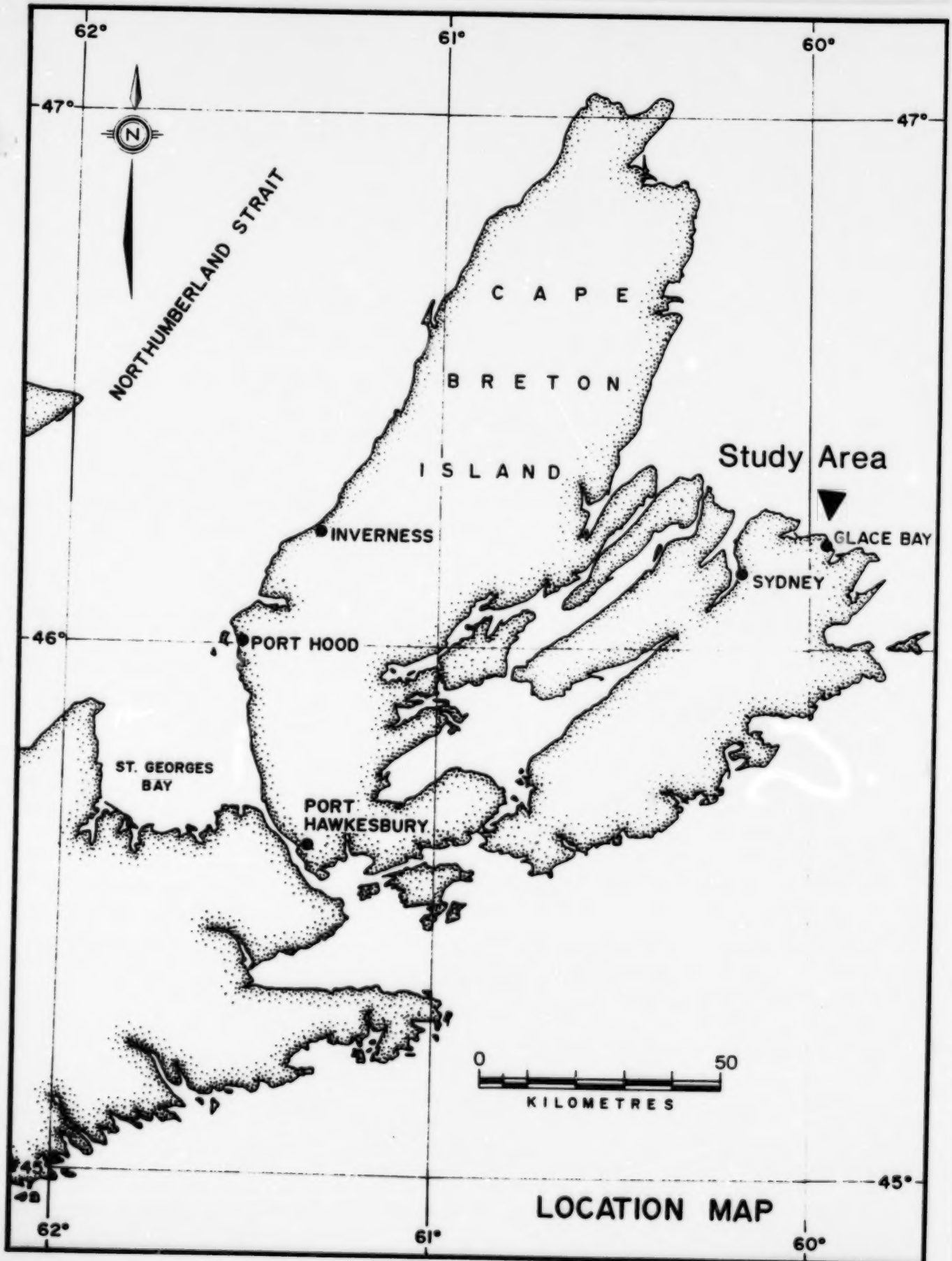
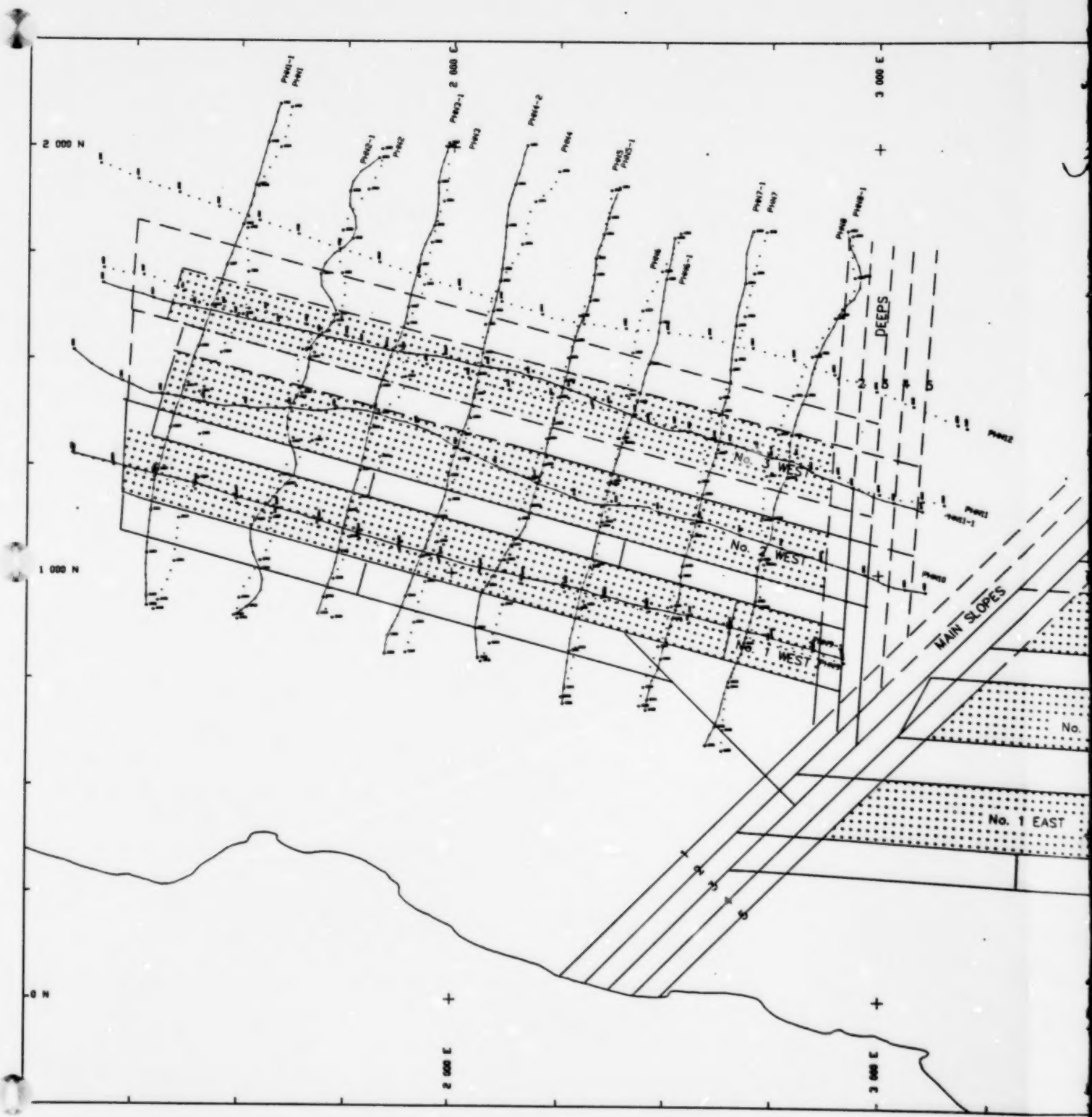

62°
61°
60°
47°
47°
N
NORTHUMBERLAND STRAIT
CAPE
BRETON
ISLAND
Study Area
INVERNESS
GLACE BAY
SYDNEY
46°
PORT HOOD
ST. GEORGES
BAY
PORT
HAWKESBURY
0
50
KILOMETRES
45°
45°
LOCATION MAP
62°
61°
60°

FIGURE 1


2 000 N
1 000 N
0 N
2 000 E
3 000 E
PW1-1
PW1
PW2-1
PW2
PW3-1
PW3
PW4-2
PW4
PW5
PW5-1
PW6
PW6-1
PW7-1
PW7
PW8
PW8-1
PW9
PW9-1
PW10
PW11
PW11-1
PW12
DEEPS
No. 3 WEST
No. 2 WEST
No. 1 WEST
MAIN SLOPES
No.
No. 1 EAST

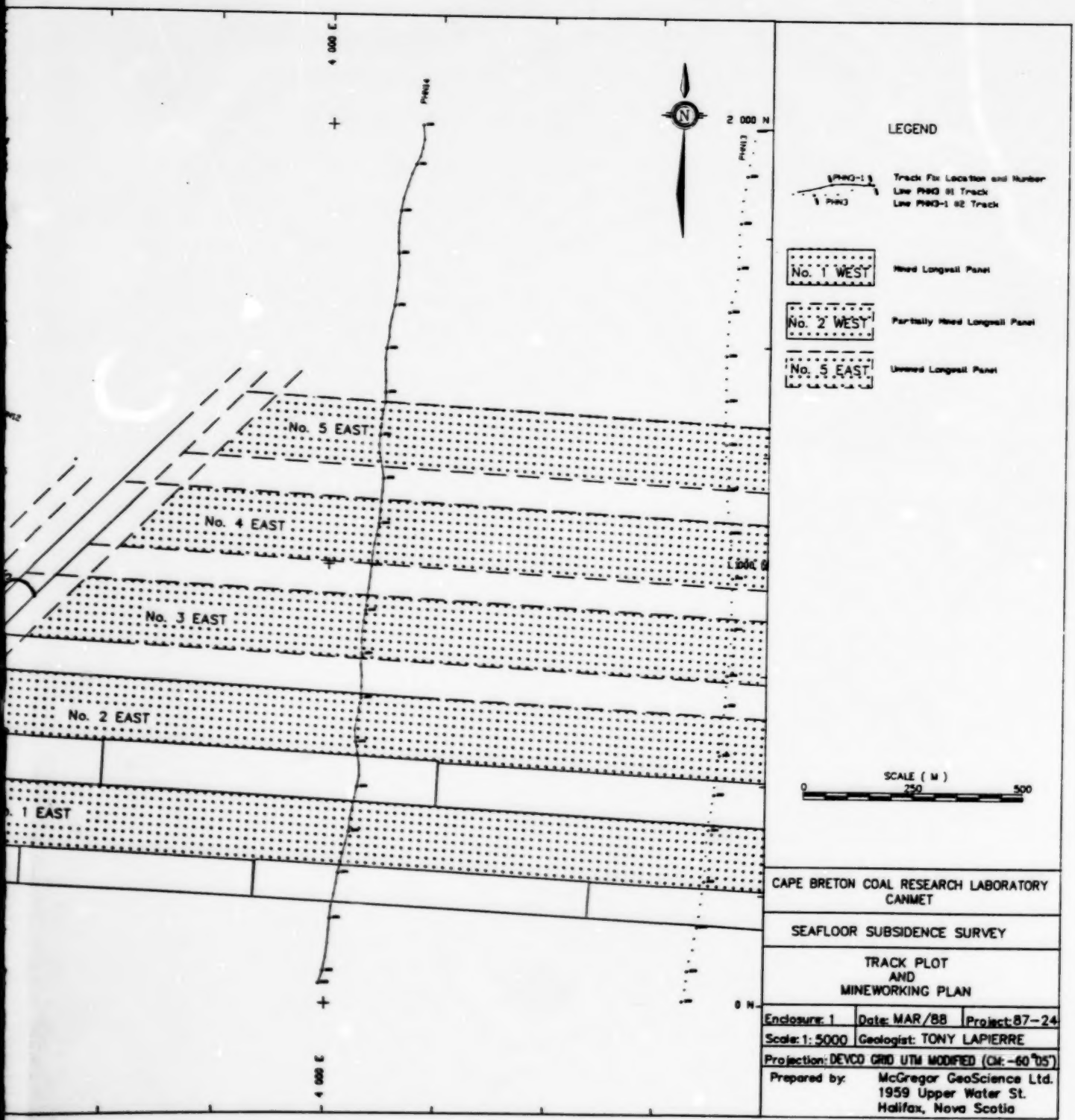

4 000 E
2 000 N
0 N
No. 5 EAST
No. 4 EAST
No. 3 EAST
No. 2 EAST
1 EAST
LEGEND
Track Fix Location and Number
Line PHN3-01 Track
Line PHN3-02 Track
No. 1 WEST
Mined Longwall Panel
No. 2 WEST
Partially Mined Longwall Panel
No. 5 EAST
Unmined Longwall Panel
SCALE ( M )
0
250
500
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
SEAFLOOR SUBSIDENCE SURVEY
TRACK PLOT
AND
MINEWORKING PLAN
Enclosure: 1
Date: MAR/88
Project: 87-24
Scale: 1: 5000
Geologist: TONY LAPIERRE
Projection: DEVCO GRID UTM MODIFIED (CM: -60°05')
Prepared by:
McGregor GeoScience Ltd.
1959 Upper Water St.
Halifax, Nova Scotia

**FIGURE 2**

## SECTION 2

## ECHOSOUNDER PROFILES

A Krupp Atlas, Deso 20 echosounding system was utilized to acquire high quality bathymetric data throughout the site. The recording scales were selected to maximize horizontal and vertical resolution of seafloor topography. Figure 3 is an example record which displays the complex microtopography resulting from outcropping beds of northward-dipping Carboniferous strata. This example also illustrates the degrading effect of vessel pitch and roll on the echosounder profiles.

### 2.1 Digitizing

The echosounder profiles were digitized on a digitizing table at a high sample rate to permit compensation for changing horizontal scales which varied as the survey vessel's speed over the bottom varied and thus to permit direct comparison of line re-runs.

Tracings of the bottom profiles were made on overlays prior to digitizing. These overlays indicate the position of the seafloor selected by the interpreter, permitting greater efficiency in digitizing, improved quality control and flexibility in editing while avoiding defacement of the original records. The effects of vessel pitch and roll were "filtered out" in this process of the interpreter drawing the "best fit" line through the sinuous bottom trace.

Line PHN7
Rough Sea
Line PHN 7-1
Calmer Sea
Heave
50cm
25metres
25metres
N
S
1001
1002
1003
1004
1001
1002
1003

FIGURE 3

The records were digitized in the point-digitizing mode with point spacing varied as dictated by seafloor complexity and time limitations. Generally the digitizing increment ranged from 1 to 2 metres horizontal.

## 2.2 Data Reduction

The digital files of water depth created in the digitizing process were corrected for tidal variation. The tidal corrections applied were prepared by the Marine Environmental Data Service (MEDS), Ottawa, Ontario and supplied through the Canadian Hydrographic Service, Dartmouth, Nova Scotia. The North Sydney permanent tide gauge was selected because of its close proximity to the survey site.

The short time duration over which each line was acquired, permitted single, bulk shifts in tidal elevation to be applied. The tidal correction calculated at the line's midtime was applied to the entire line. Table 2-2, Appendix 2 gives the tidal data for these data reductions. The range in tidal elevation during the survey period was approximately 0.84 metres maximum (between high and low tide). Typical line duration was only 15 minutes so it is believed that the simple tidal correction applied is appropriate.

Problems were initially encountered in the measurement of speed of sound in seawater by bar check at the site during the first two days of the survey. Due to this, the echosounder system was operated with an assumed velocity for speed of sound in seawater of 1400 m/s. After revising the bar check methodology, an accurate velocity of 1457 m/s was obtained. As a result of this the raw echosounder records differ in their datum, depending on when they

were collected. To correct this difference the digital values for water depth obtained prior to determining the correct water velocity were adjusted to standardize the water depth measurement based on a velocity of 1457 m/s. All editing of the water depth data was done on a digital file of water depth and geographic coordinates using dBASE III software.

## SECTION 3

## TRACK PLOTS

The track plots of the survey site are provided as Enclosures 1 and 2. Two separate maps are used to differentiate the repeated lines; Enclosure 1 displays the south- and west-headed lines and Enclosure 2, the north- and east-headed lines. Since most lines were repeated in an opposite direction, the lines are differentiated on the track plots as in the following example:

First run: Line 2
Second run: Line 2.1

These track maps were digitized on a digitizing table employing Supertech software to provide digital files of event mark locations; that is, at the points where the echosounder and boomer profiles were simultaneously marked and navigation position recorded.

## SECTION 4

## PLAN AND PROFILE PANEL DEVELOPMENT

The digitized survey track files were used along with the digitized echosounder profile values to produce individual line, plan and profile panels. These panels were composed by exporting the digital data contained in Supertech files, to the CAD software system - AutoCad. Each finished panel was subsequently recorded in digital form as an AutoCad drawing file. These lines. Panels 1 through 14 display the track plan and superimposed bathymetric profiles of lines PHN 1 (PHN 1-1) to PHN 9 (PHN 9-1), PHN 10*, PHN 11 (PHN 11-1), PHN 12* to PHN 14*. These panels, plotted at scales of 1:1000 (horizontal) and 1:50 (vertical) have been deposited with the Scientific Authority. A single, full size panel is included in this report as Enclosure 3 (Plan and Profile Panel: Line 5 and 5-1). Photographically-reduced versions of panels 1 through 9 and panel 11 are included herein as Figures 4 through 12.

The production of these panels is an important milestone in the project because they establish all pre-mining seafloor topography data in AutoCad drawing file, to which post-mining profiles can be readily added for direct comparison. The AutoCad drawing source data, recorded as dBASE III files also offer the potential for further editing or for statistical comparison of profiles.

Copies of AutoCad drawing files, the digital track plot files and digital depth files are stored on IBM PC AT-generated diskettes and are deposited with the Scientific Authority.

* Single lines only.

## 4.1 Discussion of Panels

The upper portion of each panel displays a rotated plan map of the survey line tracks. The lines were duplicated to test the repeatability of vessel guidance, positioning system and echosounder profile.

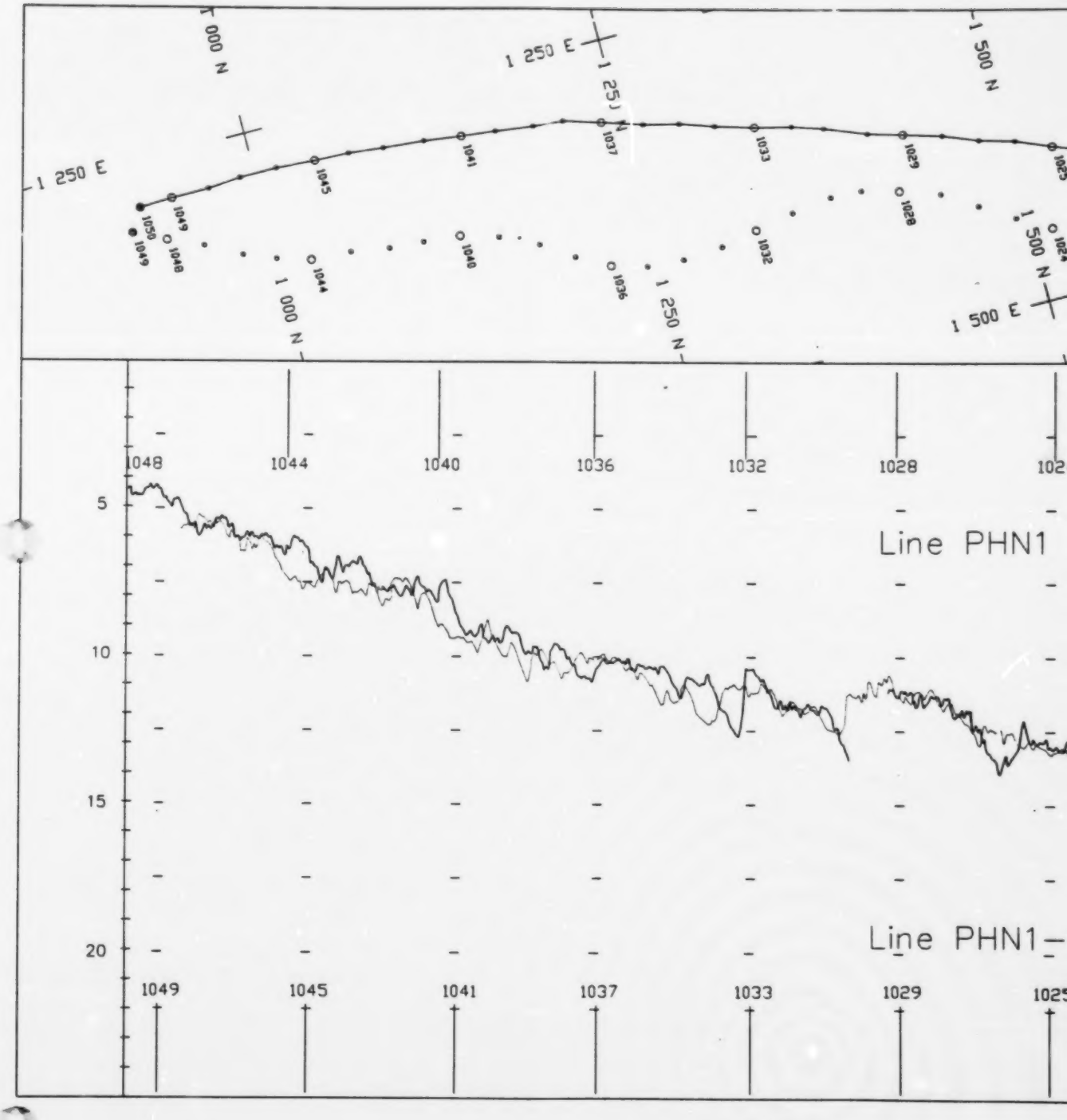
Line steering problems were encountered early in the survey. The tracks of lines 1 and 2 reflect this. This problem resulted from the vessel's helmsman overcompensating while steering the vessel with the aid of a line-steering monitor. Line-steering monitors are used extensively in marine geophysical surveys and are invaluable to an experienced operator. However in this survey it was found more effective to have the helmsman bring the vessel to the start of the line via the monitor and then to steer the line on a compass bearing. The navigator constantly monitored the vessel's position and guided the helmsman with minor course adjustments. Using this method, line-steering and repeatability was vastly improved. This is shown in the comparison of repeated lines in Panels 1 through 8 (Figures 4 through 11).

As would be expected, the degree to which repeated line tracks coincide, directly affects the degree of profile repeatability. This is evident for the dip lines; Panels 3 through 8 (Figures 6 through 11). Where track lines are superposed or nearly so; e.g., the northern half of Line 5 (Figure 8 and Enclosure 3), the profiles are nearly identical in morphology and depth with all major and most minor topographic features preserved. Contrasts between these examples are typically between 0.25 m and 0.50 m. These variations can be

accounted for by variations in the vessel heave (and hence in the degree of smoothing applied to the echosounder profile by the interpreter), inherent inaccuracy in even the highest resolution navigation equipment, complex microtopographic variations, etc.

The seafloor outcroppings of bedrock dip in a northward direction. Thus the north-south trending lines represent dip lines and the east-west trending lines represent strike lines.

In contrast to the dip line profile pairs (i.e. PHN 1 (PHN 1-1) through PHN 8 (PHN 8-1)), the strike line profile pairs (i.e. PHN 9 (PHN 9-1), and PHN 11 (PHN 11-1)) (Figure 12), exhibit a lower degree of repeatability where tracks are close to being superposed. Comparison of strike line profiles is much more sensitive to line location than dip line profiles. Seafloor topographic ridges trend parallel to strike. Therefore slight offsets in the position of a strike line can make the difference between acquiring a profile along the crest of a ridge or along a flanking trough. A dip line will acquire nearly identical cross sectional profiles of the ridges and troughs whether the lines are superposed or significantly offset.


1 000 N
1 250 E
1 250 N
1 500 N
1 500 E
1049
1045
1041
1037
1033
1029
1050
1048
1044
1040
1036
1032
1028
5
10
15
20
Line PHN1
Line PHN1

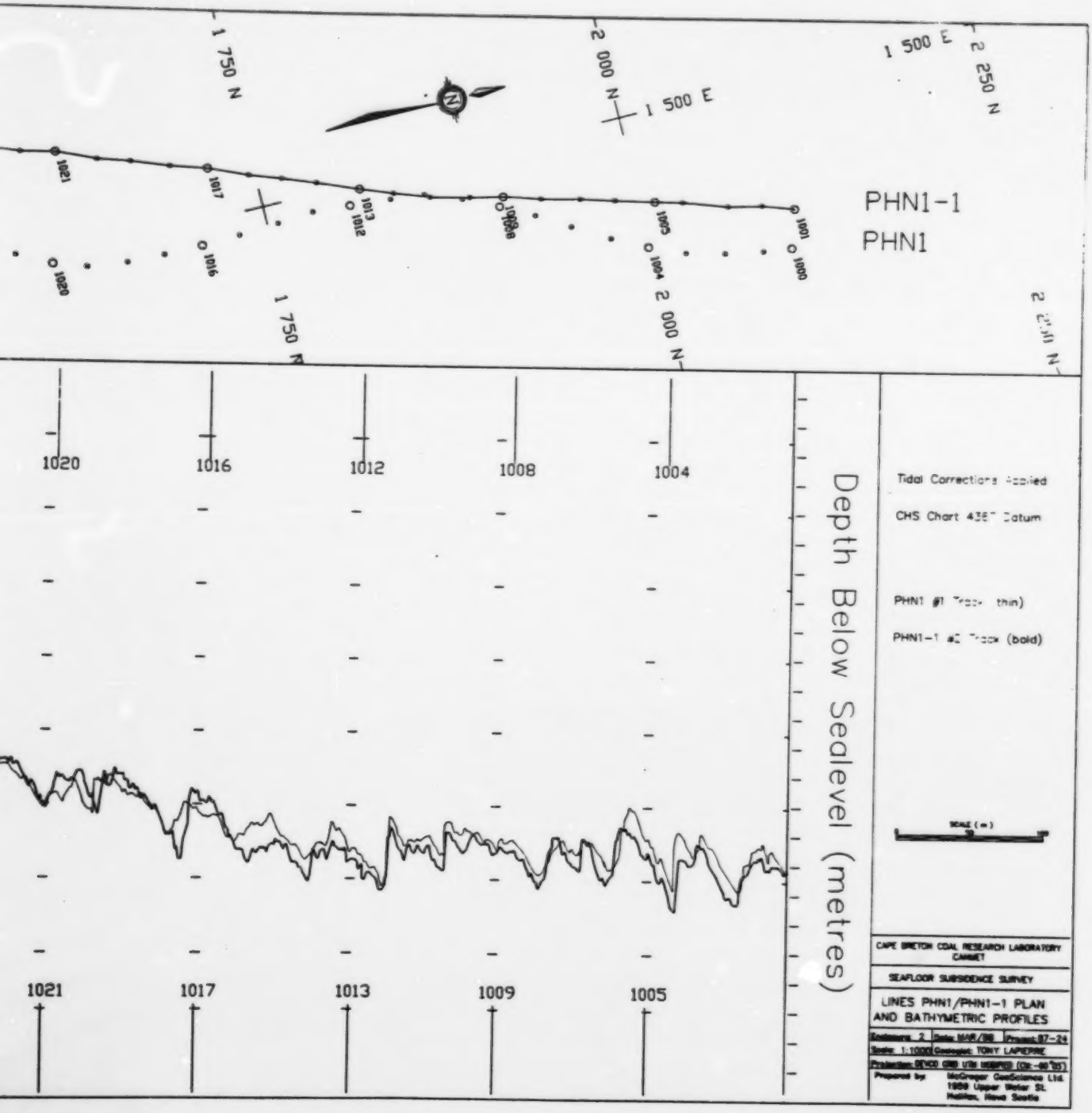
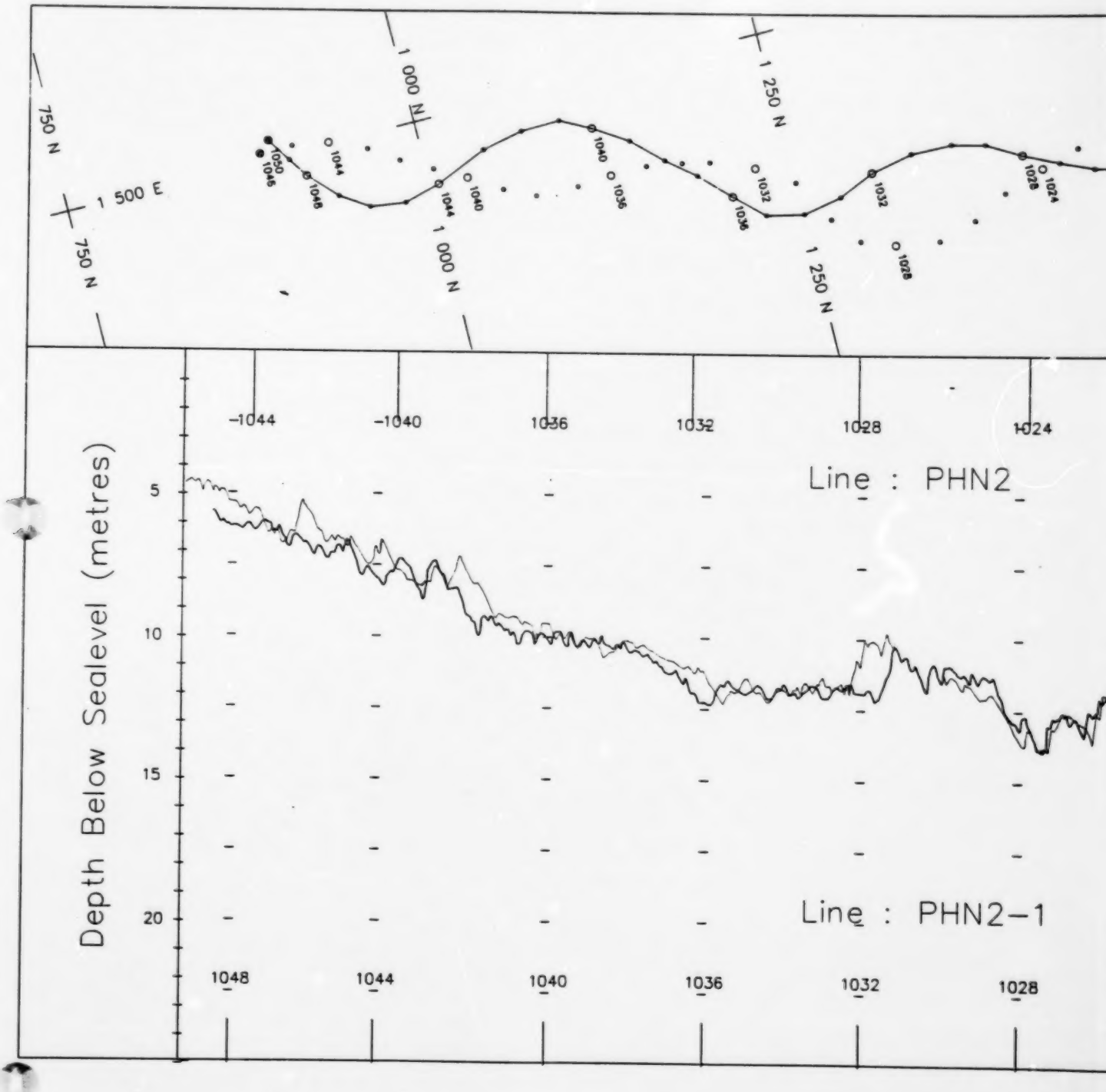

1 750 N
2 000 N
1 500 E
1 500 E
2 250 N
PHN1-1
PHN1
1021
1017
1013
1009
1005
1001
1020
1016
1012
1008
1004
1000
1020
1016
1012
1008
1004
Depth Below Sealevel (metres)
Tidal Corrections Applied
CHS Chart 4387 Datum
PHN1 #1 Track (thin)
PHN1-1 #2 Track (bold)
SCALE (m)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
SEAFLOOR SUBSIDENCE SURVEY
LINES PHN1/PHN1-1 PLAN
AND BATHYMETRIC PROFILES
Prepared by
McGregor GeoScience Ltd.
1909 Upper Water St.
Halifax, Nova Scotia

**FIGURE 4**


750 N
1 500 E
1 000 N
1 250 N
1050
1045
1048
1044
1040
1036
1032
1028
1024
-1044
-1040
1036
1032
1028
1024
Line : PHN2
Depth Below Sealevel (metres)
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10
15
20
Line : PHN2-1
1048
1044
1040
1036
1032
1028

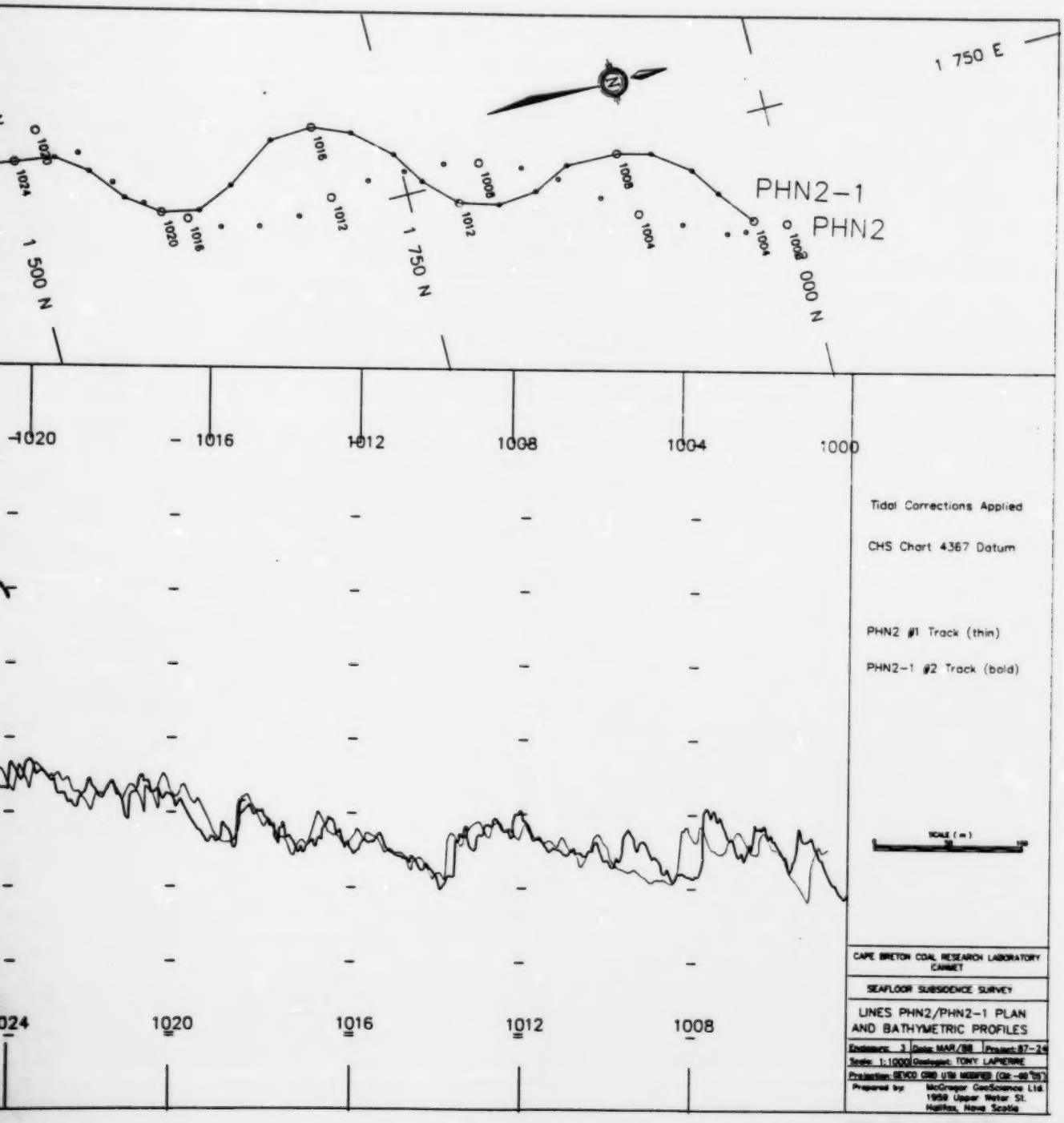
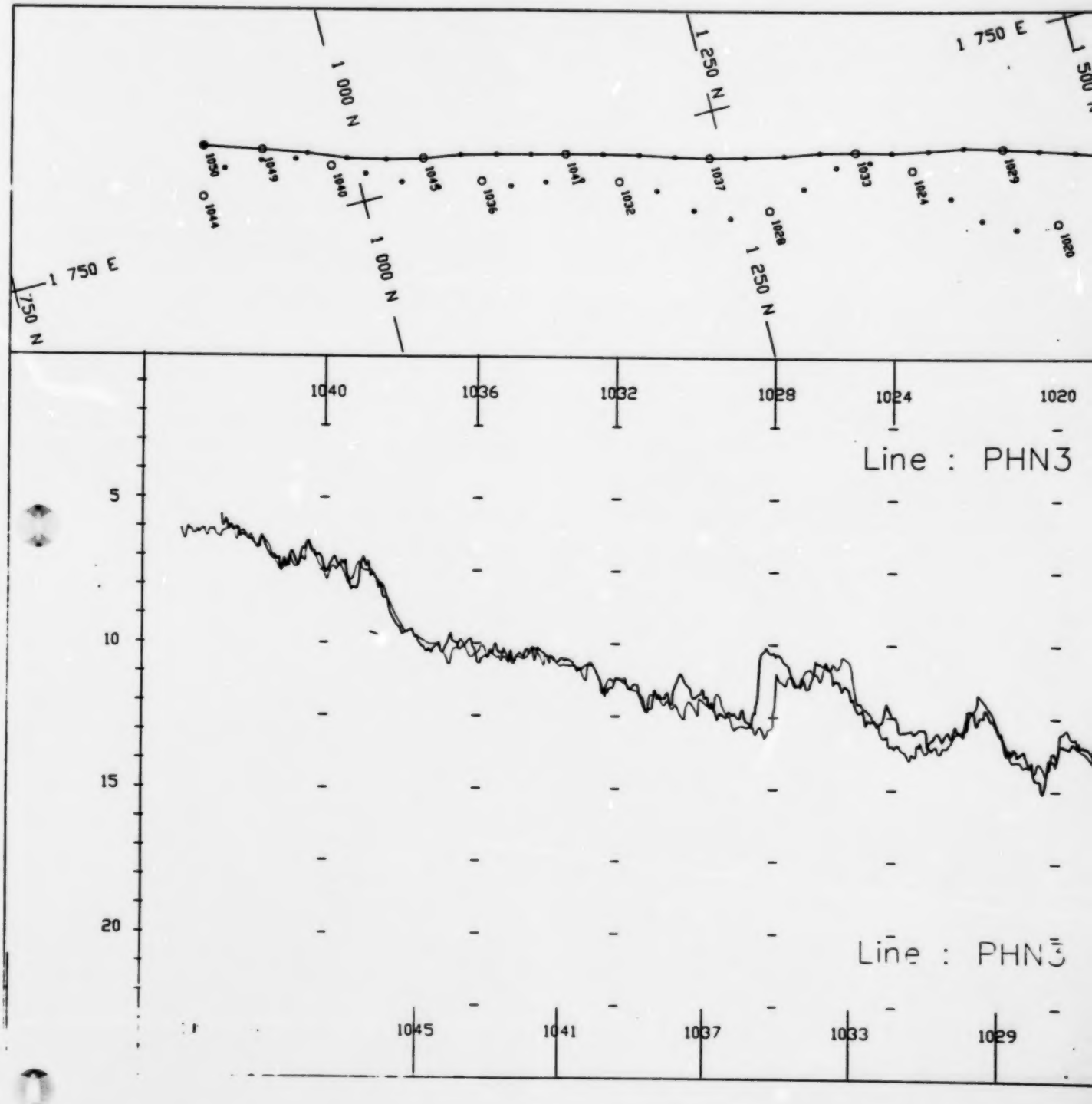

1 750 E
PHN2-1
PHN2
1 500 N
1 750 N
000 N
1020
1016
1012
1008
1004
1000
Tidal Corrections Applied
CHS Chart 4367 Datum
PHN2 #1 Track (thin)
PHN2-1 #2 Track (bold)
SCALE ( m )
CAPE BRETON COAL RESEARCH LABORATORY CANMET
SEAFLOOR SUBSIDENCE SURVEY
LINES PHN2/PHN2-1 PLAN AND BATHYMETRIC PROFILES
Enclosure: 3
Date: MAR/88
Project: 87-24
Scale: 1:1000
Geologist: TONY LAPIERRE
Prepared by: McGregor GeoScience Ltd.
1959 Upper Water St.
Halifax, Nova Scotia

**FIGURE 5**


1 750 E
1 000 N
1 250 N
1 750 E
1050
1049
1040
1044
1045
1036
1041
1032
1037
1028
1033
1024
1029
1020
1 750 E
750 N
1 000 N
1 250 N
1040
1036
1032
1028
1024
1020
Line : PHN3
5
10
15
20
Line : PHN3
1045
1041
1037
1033
1029

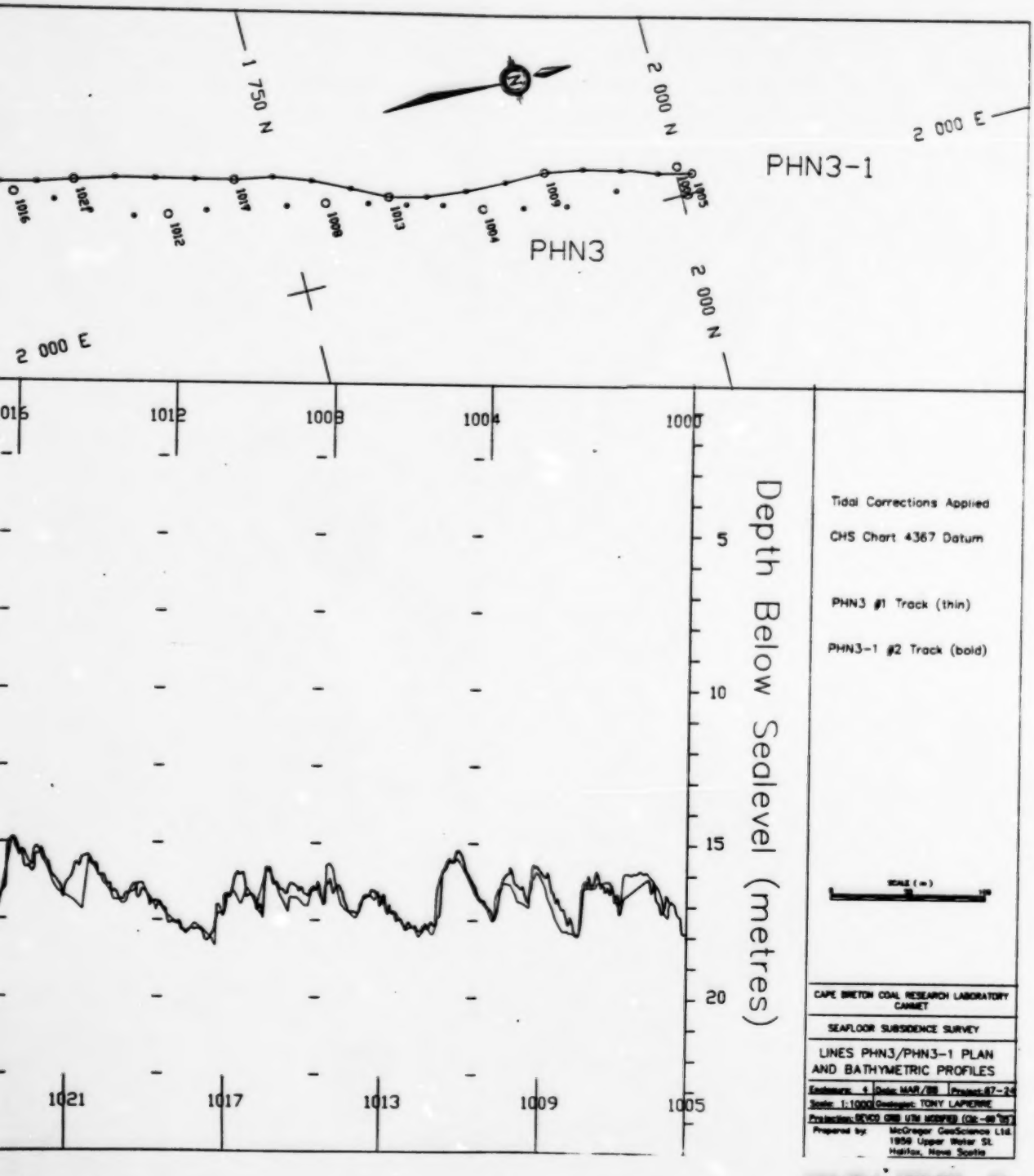
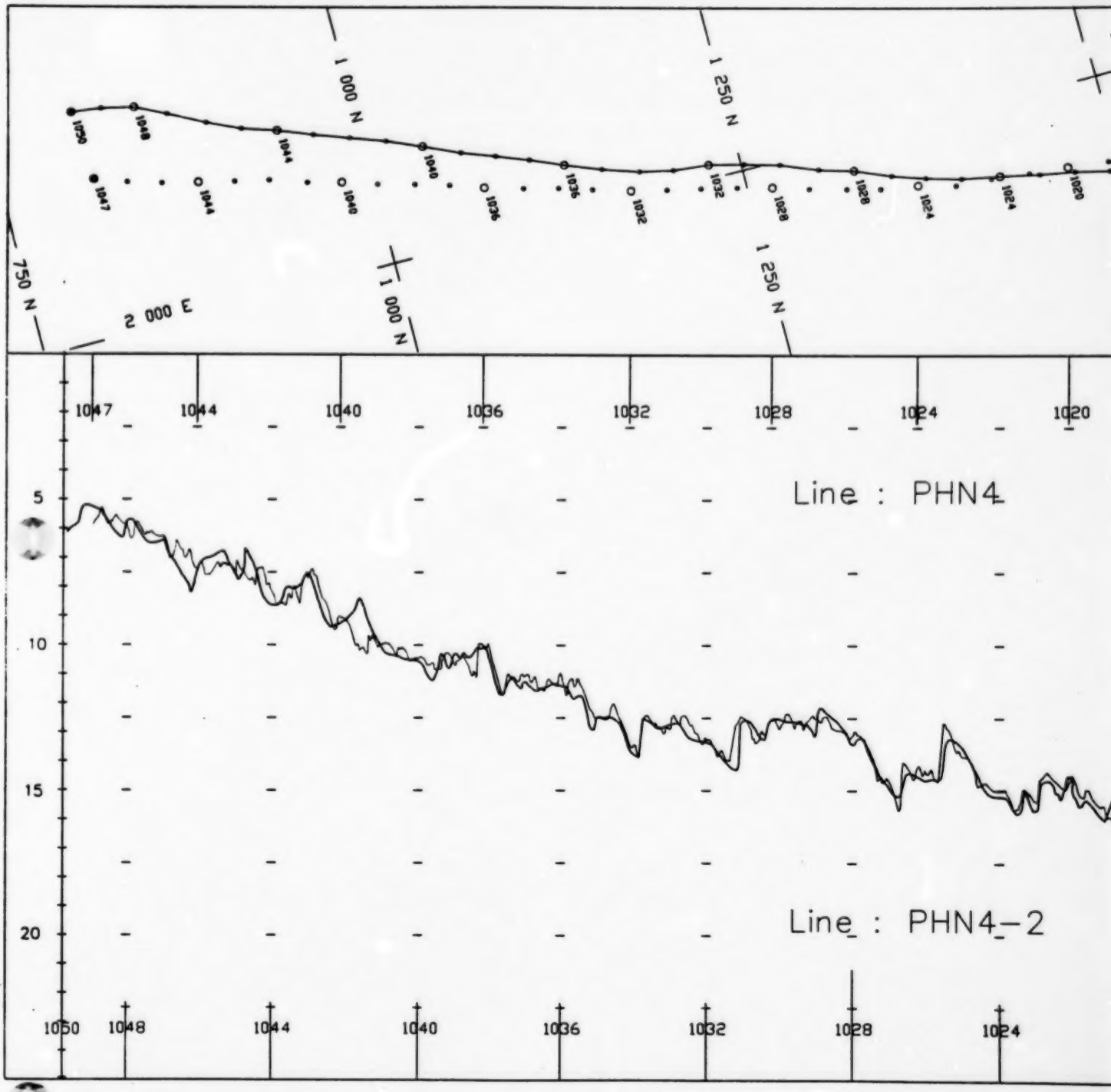

1 750 N
2 000 N
2 000 E
PHN3-1
PHN3
1016
1012
1008
1004
1000
1021
1017
1013
1009
1005
Depth Below Sealevel (metres)
5
10
15
20
Tidal Corrections Applied
CHS Chart 4367 Datum
PHN3 #1 Track (thin)
PHN3-1 #2 Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY CANMET
SEAFLOOR SUBSIDENCE SURVEY
LINES PHN3/PHN3-1 PLAN AND BATHYMETRIC PROFILES
Prepared by: McGregor GeoScience Ltd.
1959 Upper Water St.
Halifax, Nova Scotia

**FIGURE 6**


1 000 N
1 250 N
1050
1048
1044
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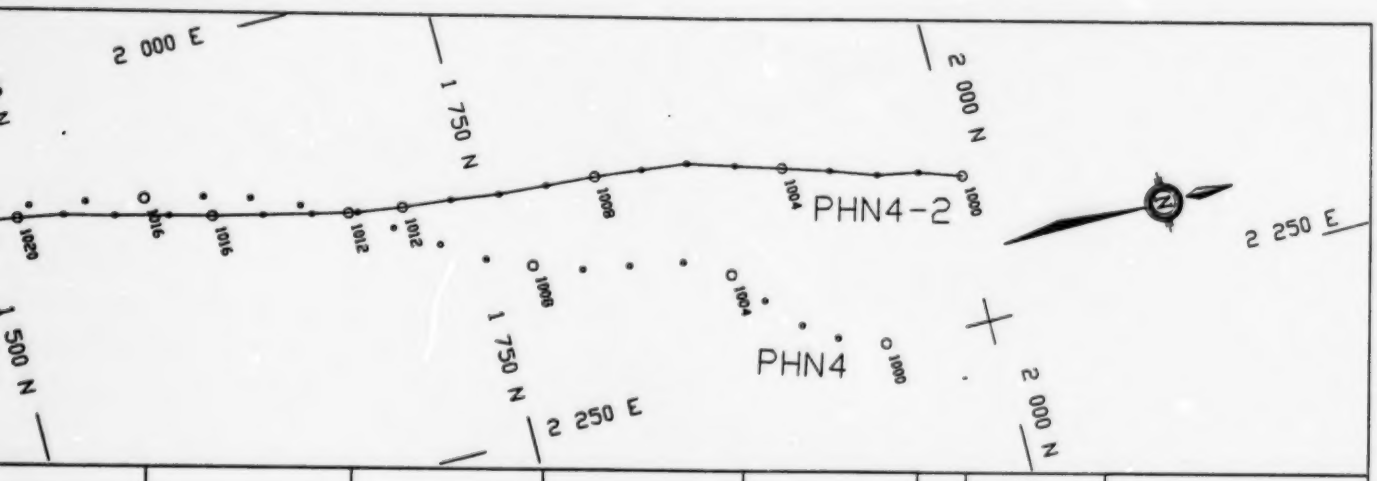
1032
1028
1024
1020
750 N
2 000 E
1 000 N
1 250 N
1047
1044
1040
1036
1032
1028
1024
1020
5
10
15
20
Line : PHN4
Line : PHN4-2
1050
1048
1044
1040
1036
1032
1028
1024


2 000 E
1 750 N
2 000 N
PHN4-2
1020
1016
1012
1008
1004
1000
2 250 E
1 500 N
PHN4

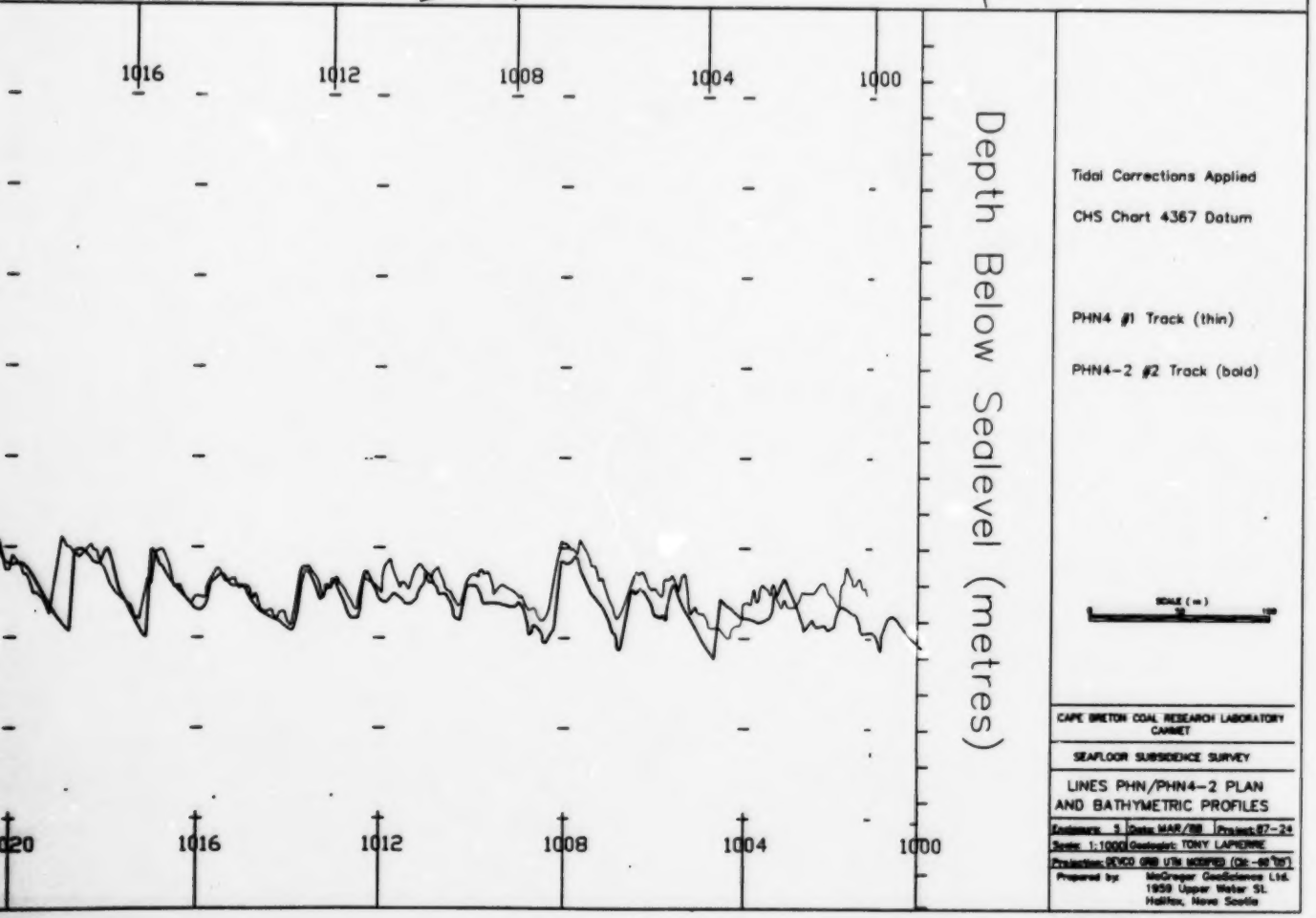
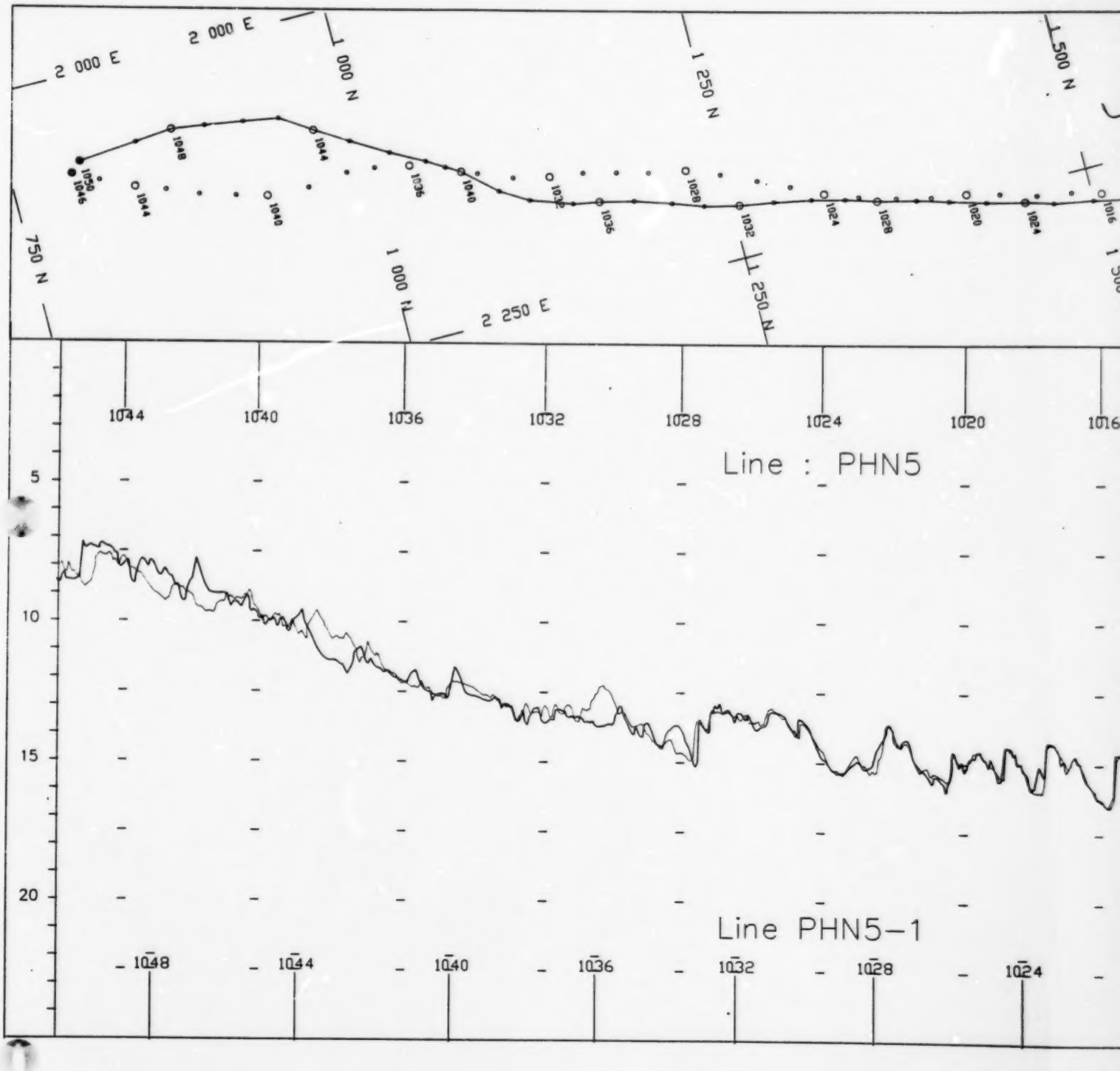

1016
1012
1008
1004
1000
Depth Below Sealevel (metres)
Tidal Corrections Applied
CHS Chart 4367 Datum
PHN4 #1 Track (thin)
PHN4-2 #2 Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
SEAFLOOR SUBSIDENCE SURVEY
LINES PHN/PHN4-2 PLAN
AND BATHYMETRIC PROFILES
Date: MAR/88
Project: 87-24
Scale: 1:1000
Geologist: TONY LAPIERRE
Prepared by:
McGregor GeoScience Ltd.
1959 Upper Water St.
Halifax, Nova Scotia

FIGURE 7


2 000 E
2 000 E
1 000 N
1 250 N
500 N
750 N
1 000 E
2 250 E
250 N
1044
1040
1036
1032
1028
1024
1020
1016
Line : PHN5
5
10
15
20
Line PHN5–1
1048
1044
1040
1036
1032
1028
1024

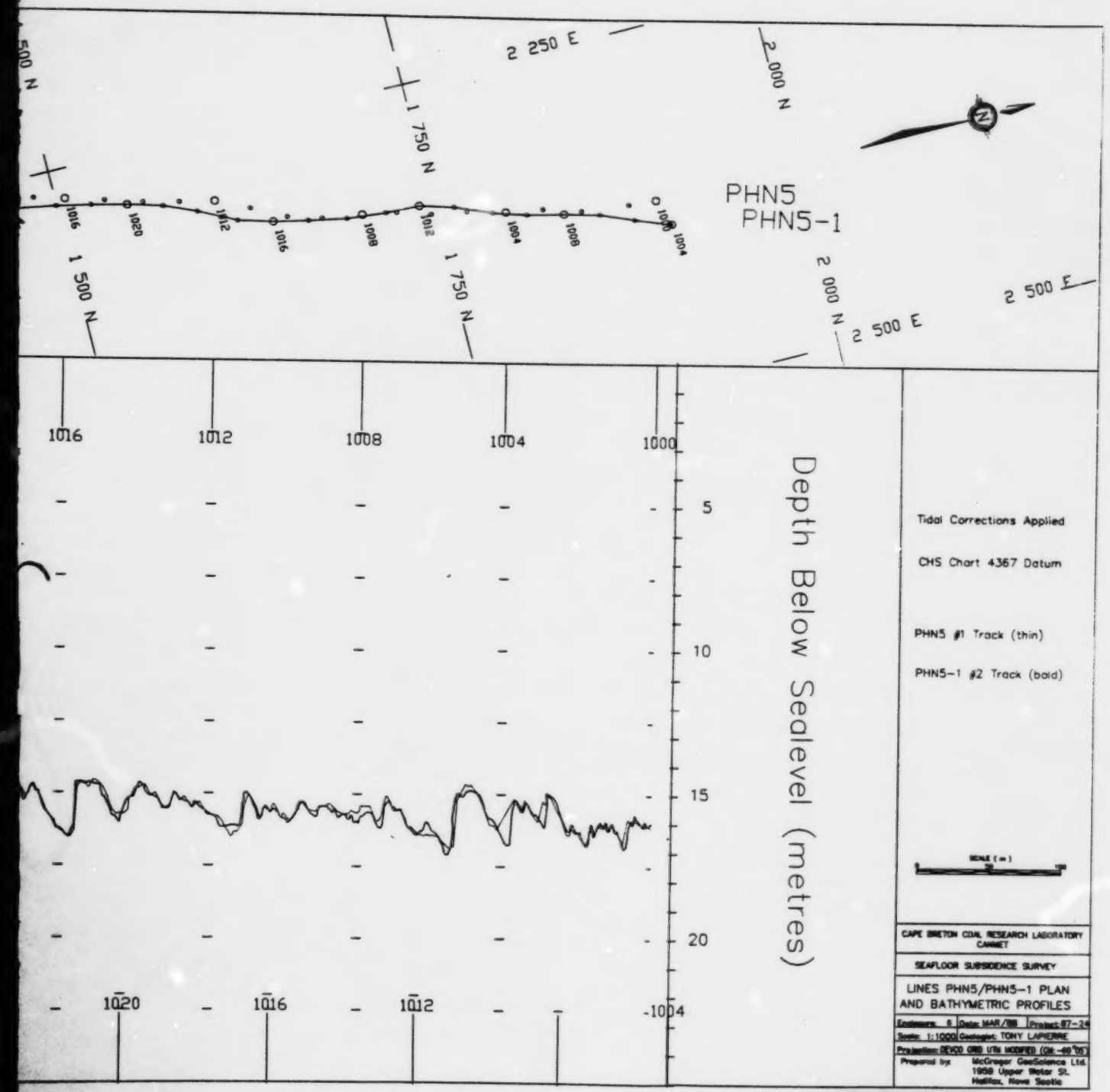
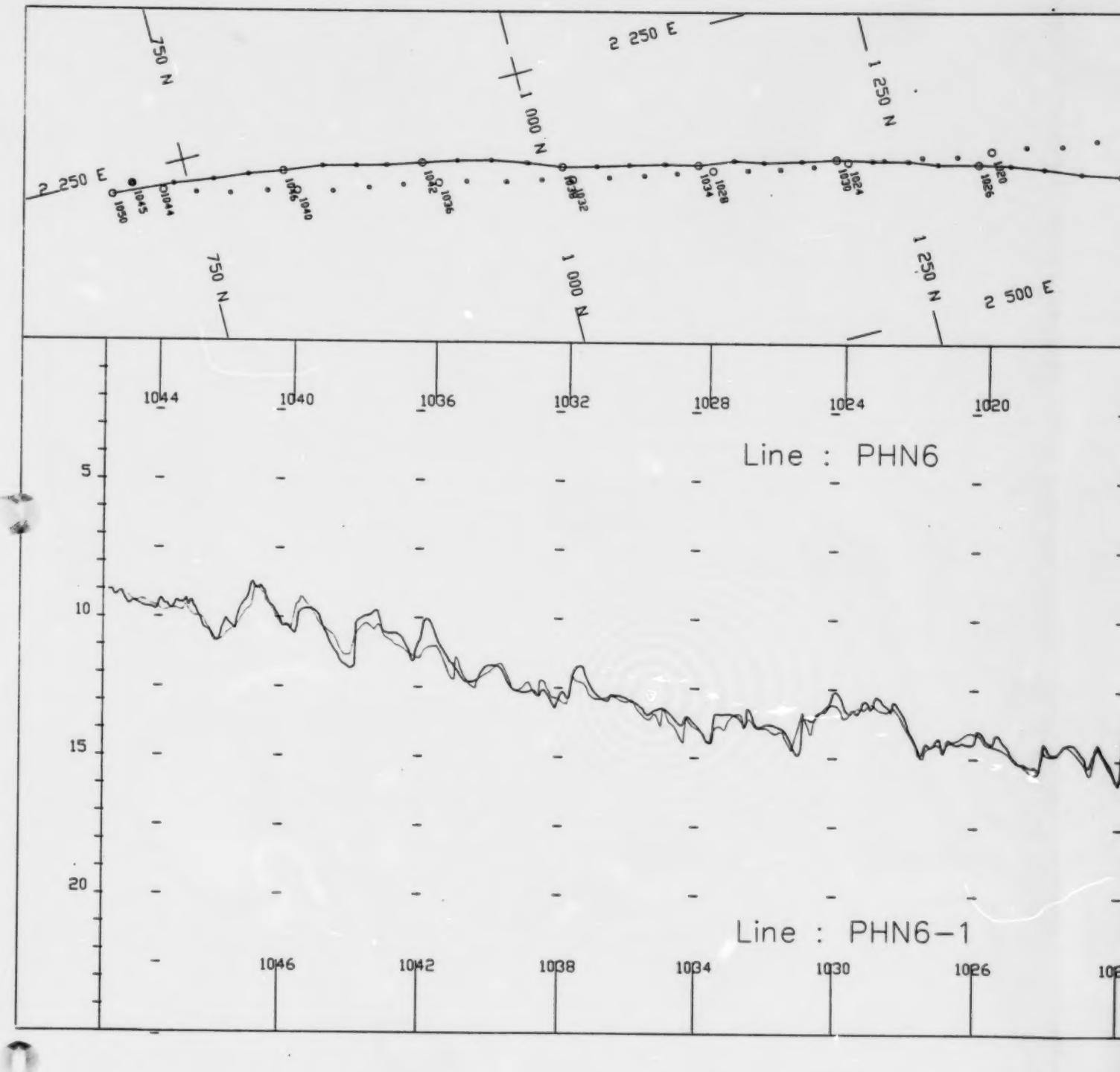

2 250 E
2 000 N
1 750 N
PHN5
PHN5-1
1 500 N
2 500 E
1016
1012
1008
1004
1000
Depth Below Sealevel (metres)
5
10
15
20
1020
1016
1012
1004
Tidal Corrections Applied
CHS Chart 4367 Datum
PHN5 #1 Track (thin)
PHN5-1 #2 Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY CANMET
SEAFLOOR SUBSIDENCE SURVEY
LINES PHN5/PHN5-1 PLAN AND BATHYMETRIC PROFILES
Enclosure: 8
Date: MAR/88
Project: 87-24
Scale: 1:1000
Geologist: TONY LAPIERRE
Prepared by: McGregor GeoScience Ltd. 1958 Upper Water St. Halifax, Nova Scotia

**FIGURE 8**


750 N
1 000 N
1 250 N
2 250 E
2 500 E
1050
1048
1046
1044
1042
1040
1038
1036
1034
1032
1030
1028
1026
1024
1022
1020
1044
1040
1036
1032
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1030
1026
Line : PHN6-1

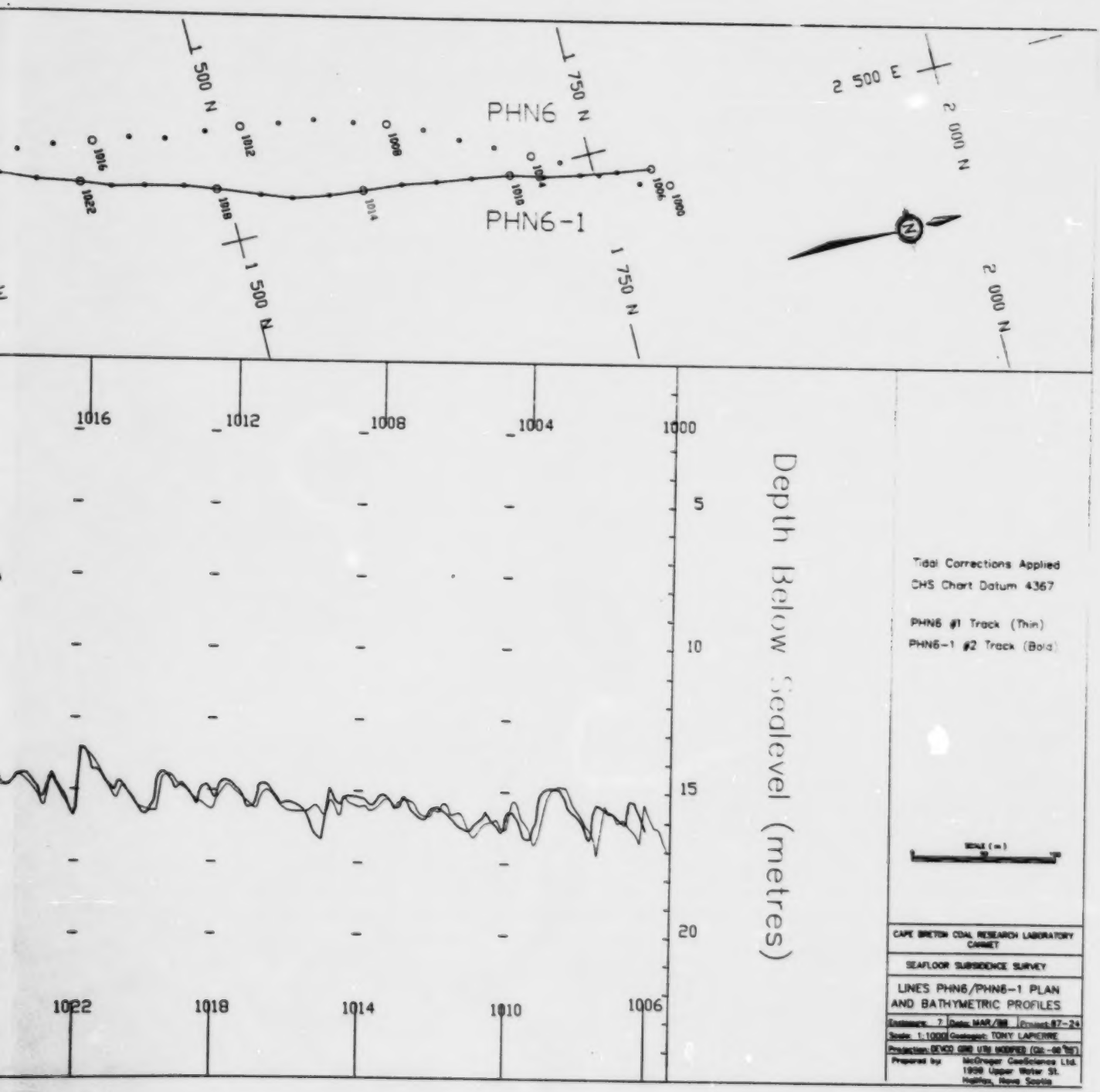
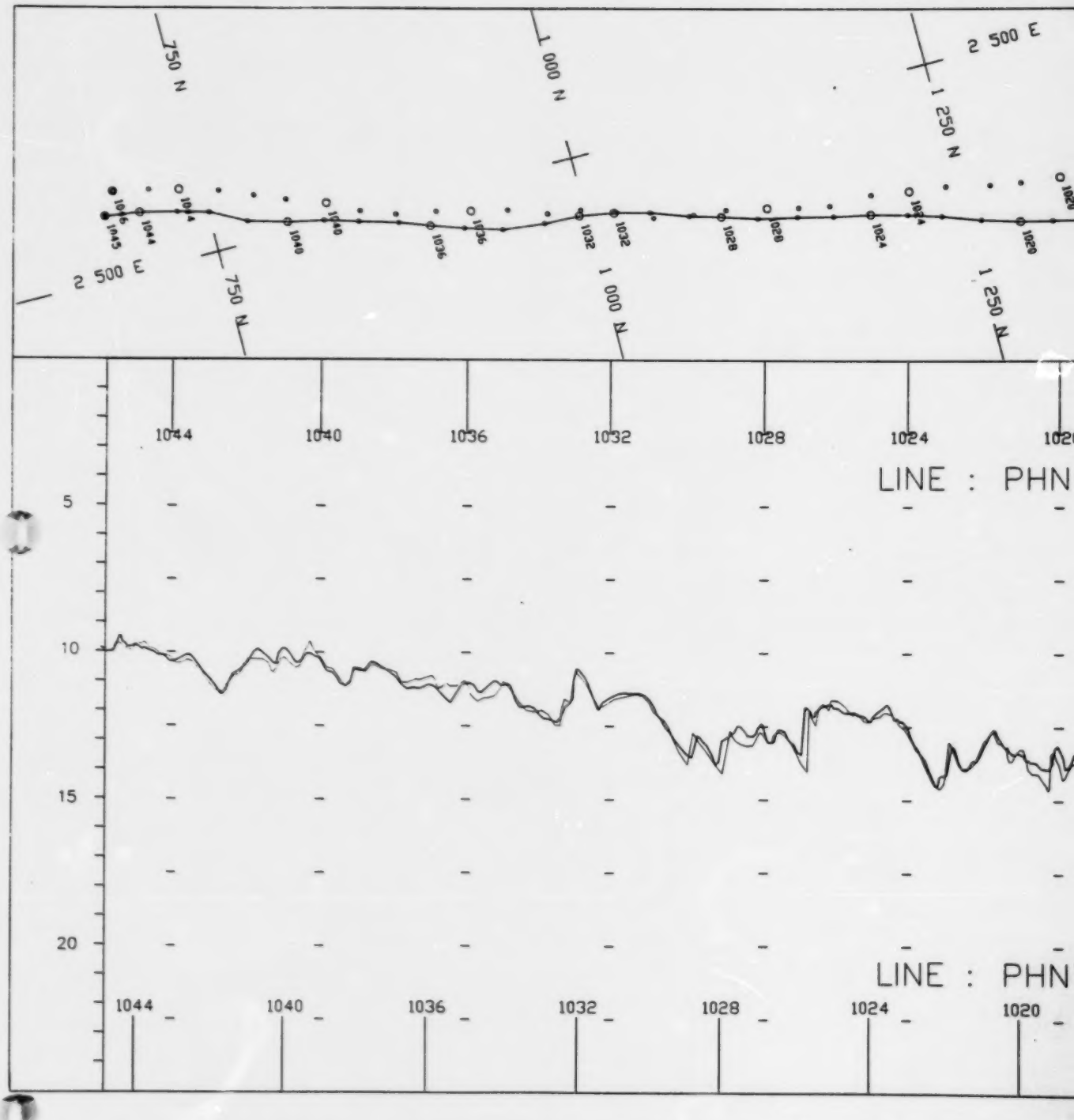

1 500 N
1 750 N
2 000 N
2 500 E
PHN6
PHN6-1
1016
1012
1008
1004
1000
1022
1018
1014
1010
1006
5
10
15
20
Depth Below Sealevel (metres)
Tidal Corrections Applied
CHS Chart Datum 4367
PHN6 #1 Track (Thin)
PHN6-1 #2 Track (Bold)
CAPE BRETON COAL RESEARCH LABORATORY CANMET
SEAFLOOR SUBSIDENCE SURVEY
LINES PHN6/PHN6-1 PLAN AND BATHYMETRIC PROFILES
Prepared by McGregor GeoScience Ltd.
1959 Upper Water St.
Halifax, Nova Scotia

**FIGURE 9**


750 N
1 000 N
1 250 N
2 500 E
2 500 E
750 N
1 000 N
1 250 N
1044
1040
1036
1032
1028
1024
LINE : PHN
5
10
15
20
LINE : PHN

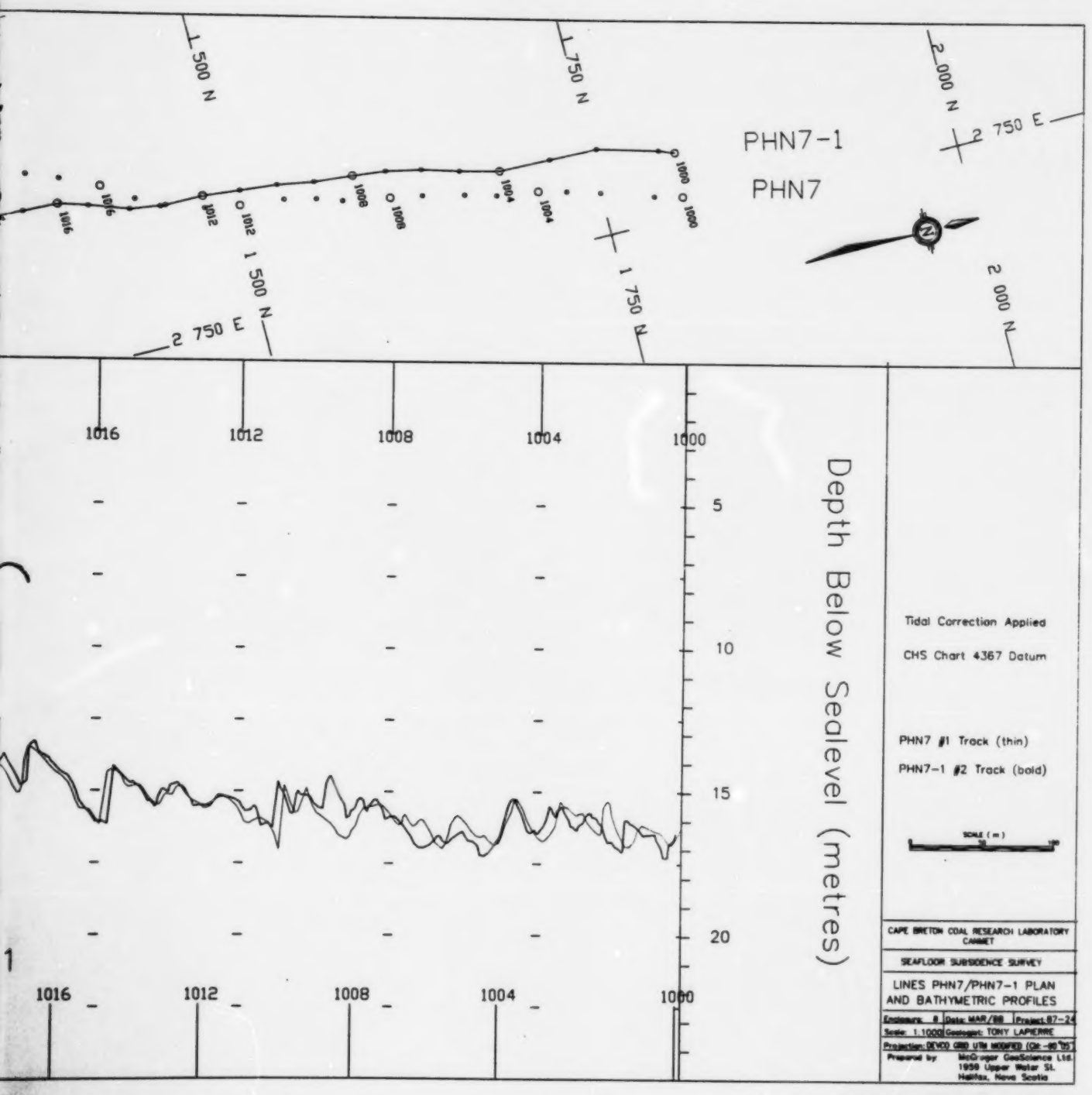
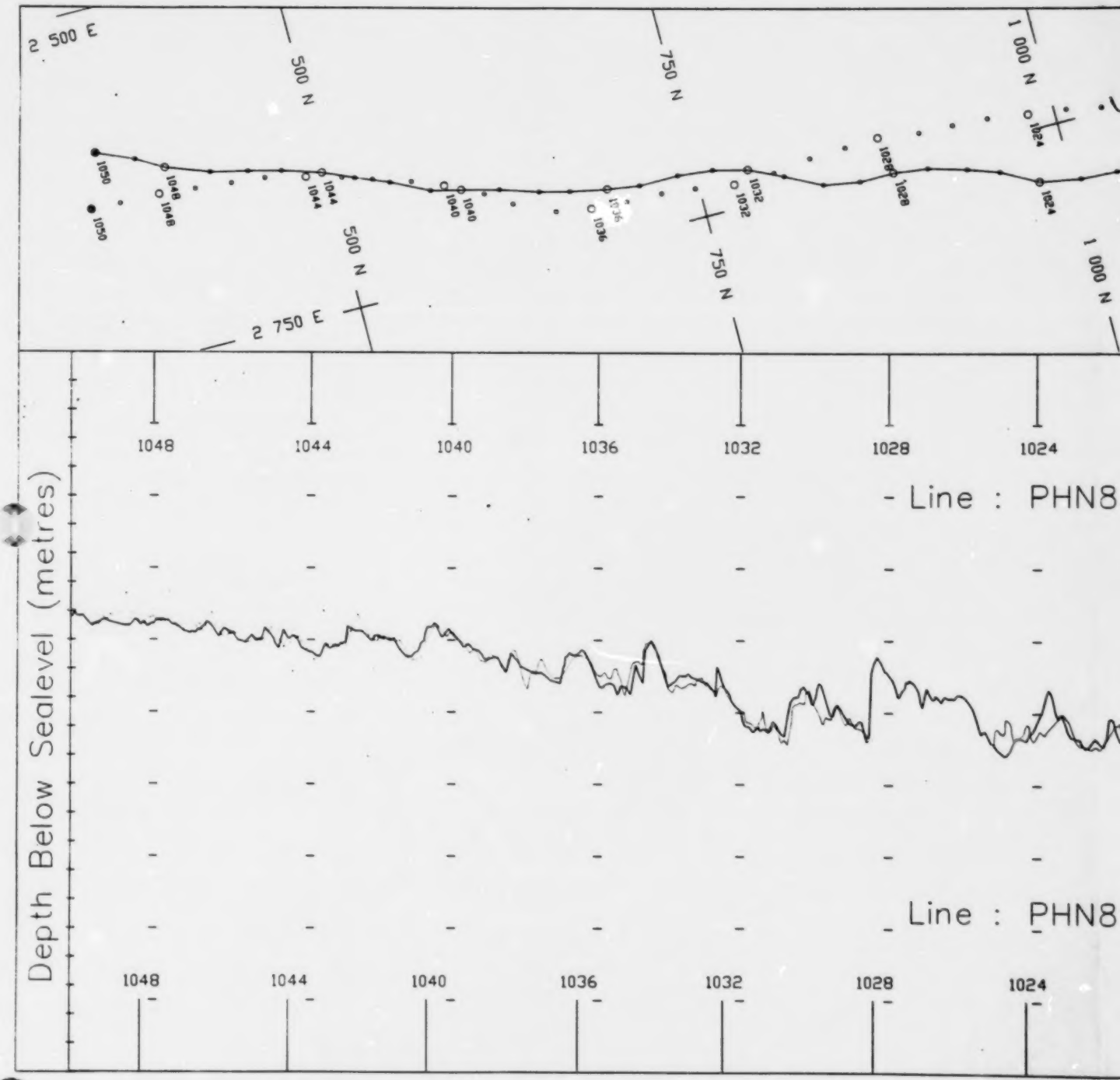

1 500 N
1 750 N
2 000 N
2 750 E
PHN7-1
PHN7
1016
1012
1008
1004
1000
5
10
15
20
Depth Below Sealevel (metres)
Tidal Correction Applied
CHS Chart 4367 Datum
PHN7 #1 Track (thin)
PHN7-1 #2 Track (bold)
SCALE ( m )
CAPE BRETON COAL RESEARCH LABORATORY CANMET
SEAFLOOR SUBSIDENCE SURVEY
LINES PHN7/PHN7-1 PLAN AND BATHYMETRIC PROFILES
Enclosure: 8 Date: MAR/88 Project: 87-24
Scale: 1:1000 Geologist: TONY LAPIERRE
Projection: DEVCO GRID UTM MODIFIED (Or: -60°30')
Prepared by: McGregor GeoScience Ltd. 1959 Upper Water St. Halifax, Nova Scotia

**FIGURE 10**


2 500 E
500 N
750 N
1 000 N
1050
1048
1044
1040
1036
1032
1028
1024
2 750 E
1048
1044
1040
1036
1032
1028
1024
- Line : PHN8
Depth Below Sealevel (metres)
Line : PHN8
1048
1044
1040
1036
1032
1028
1024

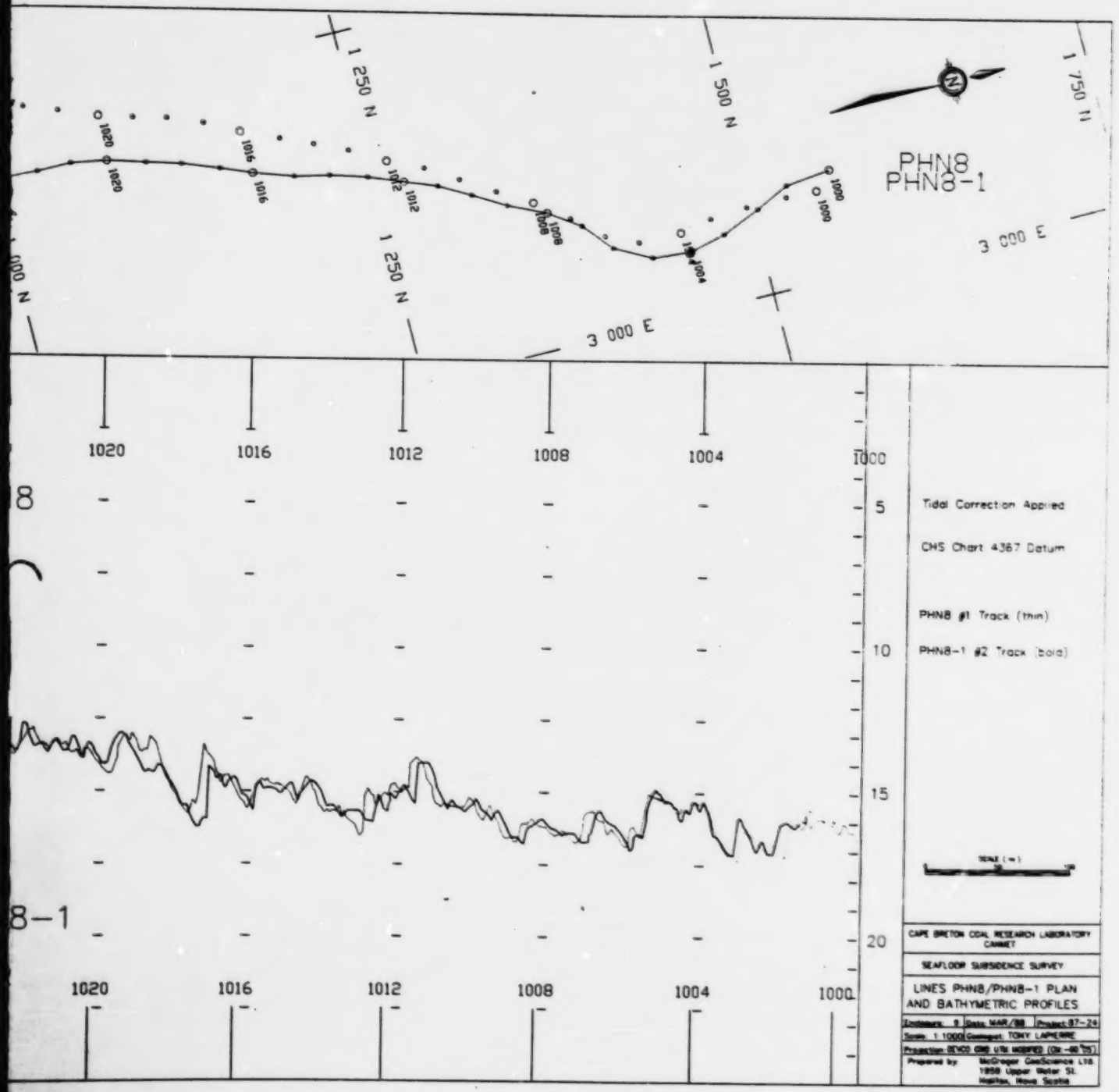
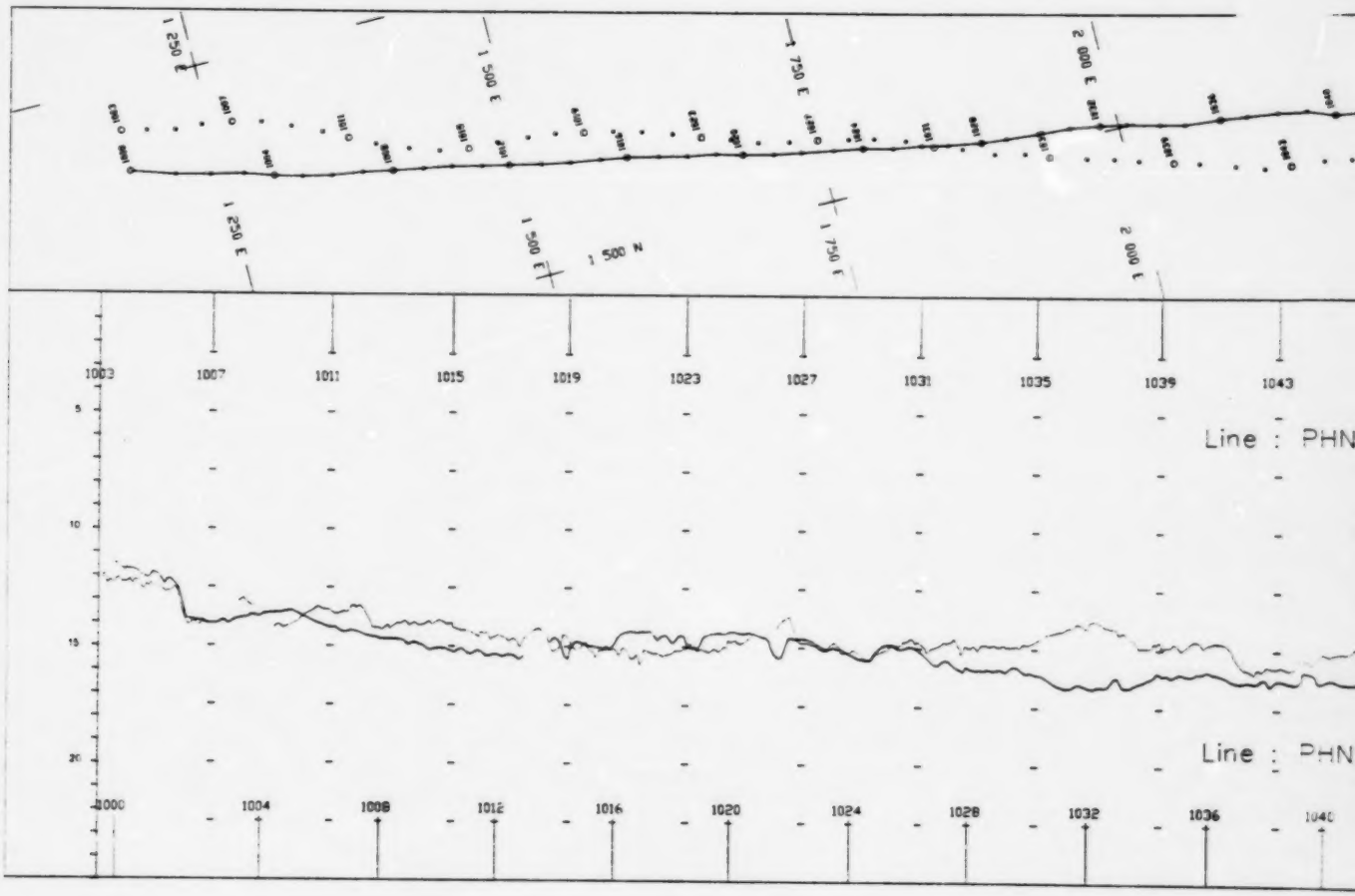

1 250 N
1 500 N
1 750 N
3 000 E
1020
1016
1012
1008
1004
1000
PHN8
PHN8-1
Tidal Correction Applied
CHS Chart 4387 Datum
PHN8 #1 Track (thin)
PHN8-1 #2 Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY CANMET
SEAFLOOR SUBSIDENCE SURVEY
LINES PHN8/PHN8-1 PLAN AND BATHYMETRIC PROFILES

**FIGURE 11**


1 250 E
1 500 E
1 750 E
2 000 E
1 500 N
1003
1007
1011
1015
1019
1023
1027
1031
1035
1039
1043
Line : PHN
Line : PHN
1000
1004
1008
1012
1016
1020
1024
1028
1032
1036
1040

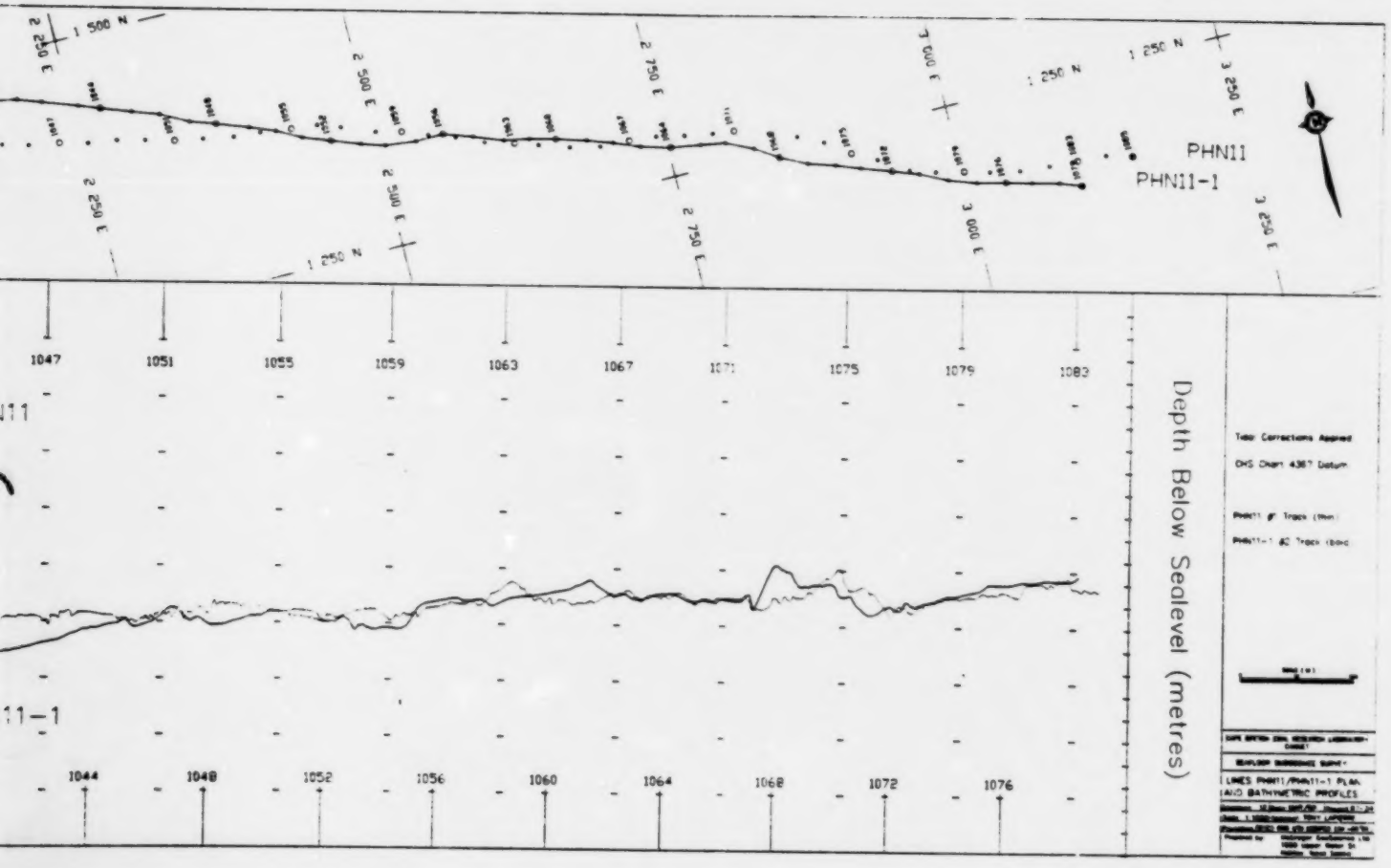

1 500 N
2 500 E
2 750 E
3 000 E
1 250 N
3 250 E
PHN11
PHN11-1
1047
1051
1055
1059
1063
1067
1071
1075
1079
1083
1044
1048
1052
1056
1060
1064
1068
1072
1076
Depth Below Sealevel (metres)

FIGURE 12

## SECTION 5

## BOOMER RECORDS

### 5.1 Interpretation of Boomer Records

The analysis of pre- and post-mining seafloor topography to detect and measure mining-induced subsidence, requires that the seafloor be uneffected by anything except subseafloor mining. This prerequisite is met only if stable bedrock outcrops at the seafloor. Our subsidence detection and measurement method would be cast into doubt in areas of sediment cover because these areas could be modified by sediment transport.

To establish whether bedrock or sediment occurs at the seafloor in the survey area, a subbottom profiling system, the ORE Geopulse Boomer system, was used. Boomer profiles were collected along all tracks in the survey area.

Bedrock in the survey area is characterized by an assymetric sawtooth, seafloor profile on echosounhder profiles. On the Boomer profiles, intermittent, planar, northward-dipping bedrock reflectors are commonly observed in the subsurface (Figure 13). Bedrock occurs at the seafloor above most of the western Phalen Colliery workings. East of 2200 E and immediately north of the #3W panel's northern margin, some bedrock surface channeling appears to occur. These channel-like features are visible on PHN 11 (PHN 11-1) and PHN 12 though resolution of channel features is poor. Up to 15 metres of sediment may be present in these depressions. Further work should be conducted during the next field program to better define these features.

Boomer data acquired along lines PHN 13 and PHN 14 over Panels No. 1 East through No. 5 East indicate bedrock outcropping at the seafloor.

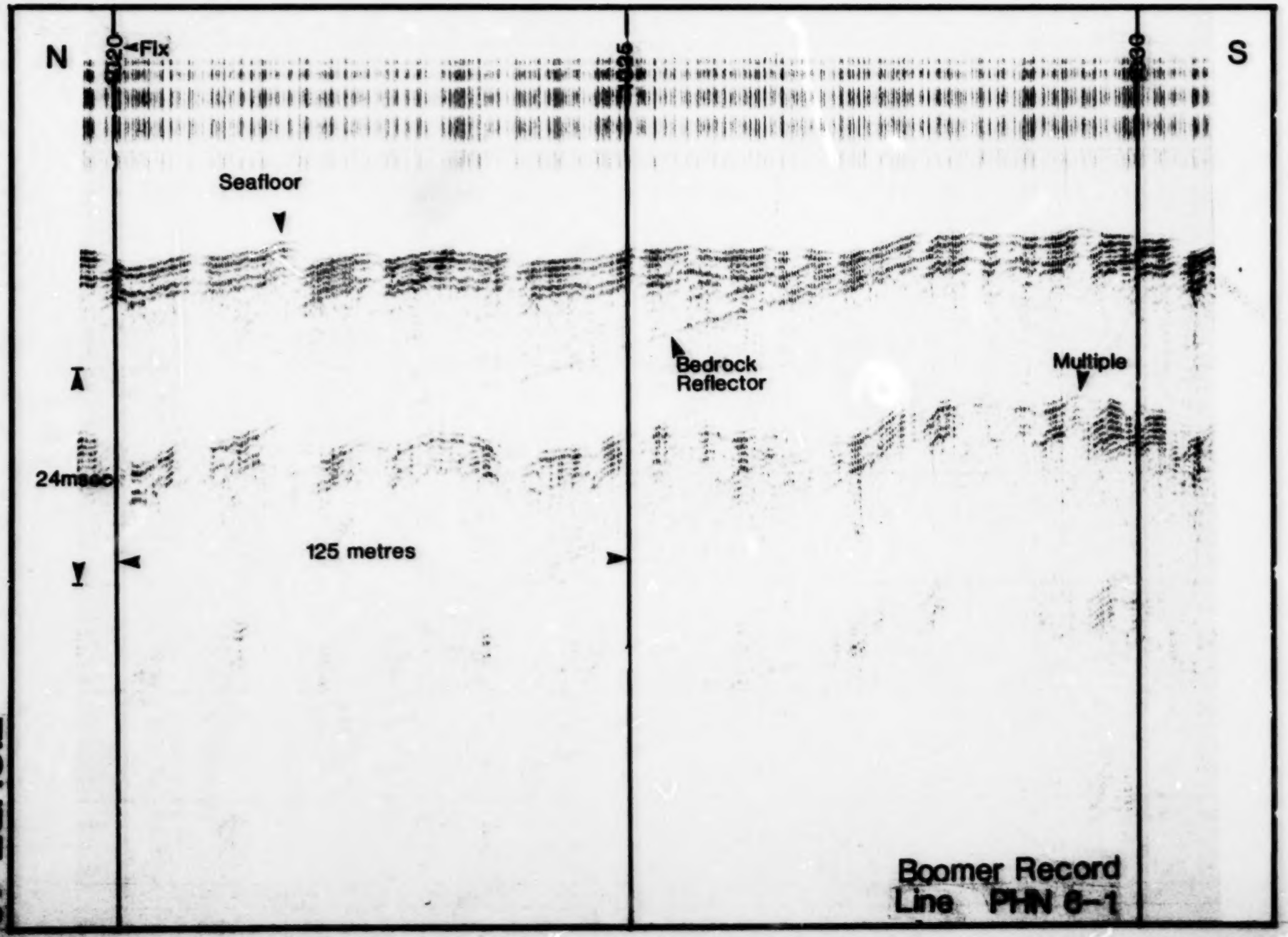

N
Fix
0200
0225
0250
S
Seafloor
Bedrock
Reflector
Multiple
24msec
125 metres
Boomer Record
Line PHN 6-1

FIGURE 13

APPENDIX 1

OPERATIONS SUMMARY



APPENDIX 1

OPERATIONS SUMMARY

| Time (Local) | |
|---|---|
| | **August 23. 1987 - Julian Day 235** |
| 0630 | Load equipment. |
| 0900 | Depart Halifax enroute to Sydney. |
| 1500 | Arrive in Sydney. |
| 1515 | Set out to locate survey markers (LRIS, CHS, GSC) appropriate for establishing Trisponder base stations. |
| 1530 | Arrive at Low Point. Position of LRIS station recently disturbed by landscaping. Station probably destroyed. |
| 1615 | Looked for next monument 1691. Not found. Site changed by vegetation since description. |
| 1700 | Monument 1614 found and flagged. |
| 1740 | North Head - two monuments - neither found. Likely covered by vegetation. |
| 1815 | Monument 19728 found and flagged. |
| 1830 | Monument 1511 found and flagged. |
| 2000 | Returned to South Bar to inspect Idle Oars II. |
| 2030 | Returned to Sydney. |
| | **August 24, 1987 - Julian Day 236** |
| 0700 | Depart Sydney for Idle Oars II in South Bar. |
| 0715 | Arrive at boat. Begin mobilization and testing of equipment. |
| 1250 | Conferred with Dr. Tim Aston, Scientific Authority. |
| 1400 | Back on board Idle Oars II. Continue testing gear. Geopulse system tested with power supply, boomer streamer, receiover and recorder. System appears to be functioning okay. Atlas Deso 20 recorder tuned. Wind still blowing 20-25 knots. White caps and swell developed. |
| 1645 | Gary Palmatary of Nortech arrives with navigation equipment. Begin loading navigation equipment and planning of Trisponder calibration survey. |
| 1730 | Master station established on South Bar Government Wharf. Slave stations established on Polar Bear Beach 1.3 km north of the Wharf for calibration purposes. |
| 2015 | Calibration of the five slave transponders and two masters completed. Return to boat. |
| 2045 | Finish loading navigation equipment used in calibration. Depart boat for Sydney. |

| Time (Local) | |
|---|---|
| | **August 25, 1987 - Julian Day 237** |
| 0800 | McGregor and Nortech personnel meet to discuss control point survey. Gary Palmatary (Nortech) along with an assistant from Cape Breton Coal Research Laboratory depart Sydney to survey the required slave station locations. |
| 0900 | Onboard Idle Oars II. Winds blowing 20 -25 knots NW. White caps developed. Continue mobilization of navigation and geophysical equipment. |
| 1230 | Mobilization and testing continued. Sea state rough in Sydney Harbour. Winds 20-25 knots NW. White caps present. |
| 1930 | Seas picking up again. Thick cloud cover encroaching. Rain (showers) anticipated. Gear covered and/or moved in boat's cabin. |
| 1945 | Depart vessel to rendezvous with control point survey team. |
| | **August 26, 1987 - Julian Day 238** |
| 0800 | Steve and Gary discuss termination of HP-DESO 20 interface. Discuss problem in that DESO 20 receives analog input for velocity whereas HP sends out digital signal; therefore, will not be able to control chart speed by boat speed via navigation. |
| 0820 | Geophysical team departs Sydney for Idle Oars II. Navigation team departs to survey last control point. |
| 0840 | Onboard Idle Oars II. Winds 20-25 knots W in Sydney Harbour. |
| 0935 | Set sail for site. Calibrate 6 element and 20 element ministreamers. Every orange tape mark corresponds to 5 m from the centre of the array. silver marks correspond to 1 m increments. |
| 0940 | Arrive offshore Phalen Colliery. Deploy sounder OTS. Tune up DESO 20 recorder. |
| 1110 | Deploy boomer and 20 element ministreamer. EPC 1600 tuned . Seas picking up 25-30 knots NW. Seas 1-2 m, whitecaps. |
| 1130 | Retrieve gear and head back to Sydney Harbour. |
| 1215 | Enroute, seas rougher. Winds strong. |
| 1310 | Tied up at South Bar wharf. Winds diminished in harbour. |
| 1600 | Waiting on weather. |
| 2000 | Seas calming in Sydney Harbour this evening. Marine forecast calling for high winds August 27 with strong winds August 28. |
| | **August 27, 1987 - Julian Day 239** |
| 0700 | Onboard vessel. Seas calm, very light wind, sun and sun showers. |
| 0810 | Depart vessel to set up Trisponder base stations. |
| 1000 | Finish setting up stations. |
| 1050 | Return to vessel. |
| 1245 | Testing of navigation continues. |

| Time (Local) | August 27, 1987 - Julian Day 239 (continued) |
|---|---|
| 1400 | Depart South Bar, heading toward site. Toward mouth of Sydney Harbour sun is shining. Temperature pleasant. Very light winds. Seas calm i.e.: < 30 cm. |
| 1455 | Arrive at site offshore Lingan Colliery. Seas still calm. Deplov echosounder. Echosounder draft = 55 cm. |
| 1500 | Bar check started. |
| 1600 | Bar check complete. |
| 1610 | All 4 transponders stations operative. Line steering program working. Geopulse system deployed. Source to starboard and Receiver to port. |
| 1635 | Winds increasing to about 10 knots E (still light winds). Sea remains < 30 cm. Geophysical equipment being tuned. Both EPCs (1600 and 3200) recording test data. Data appears to lack good penetration. Power output increase on power supply from 105 kJ to 175 kJ. |
| 1652 | Start of test line. All gear in water. Testing continues. Seas very calm, gear tuned well. |
| 1819 | Begin shooting. Start of Line (SOL) 1S (PHN 1). First Shot Point (FSP) 1000. |
| 1832 | End of line (EOL) 1S (PHN 1). Last shot point (LSP) 1049. |
| 1853 | SOL 2S (PHN 2). FSP 1000. |
| 1908 | EOL 2S (PHN 2). LSP 1048. |
| 1908 | SOL 2N. FSP 1050. Aborted at start. EOL 1050. |
| 1923 | SOL 2.1N (PHN 2-1). FSP 1050. Heading 15 degrees. |
| 1935 | EOL 2.1N (PHN 2-1). LSP 1003. Seas still very calm. No wind. |
| 1950 | SOL 3S (PHN 3). FSP 1000. Heading 195 degrees. |
| 2003 | EOL 3S (PHN 3). LSP 1044. |
| 2018 | SOL 3N (PHN 3-1). FSP 1050. Heading 15 degrees. |
| 2034 | EOL 3N (PHN 3-1). LSP 1004. End of Tape #1. Annotations are correct from EOL backwards until they become out of sequence. The numbers of of sequence from this point on must be fixed. Seas picking up. Start of Tape #2. |
| 2055 | SOL 4S (PHN 4). FSP 1000. Heading 195 degrees. |
| 2107 | EOL 4S (PHN 4). LSP 1047. |
| 2120 | SOL 4N (PHN 4-1). FSP 1050. Heading 15 degrees. |
| 2132 | EOL 4N (PHN 4-1). LSP 1001. |
| 2150 | Seas picking up. Pull in geopulse system and echosounder. |
| 2200 | Light showers. Enroute to South Bar Government Wharf. |
| 2315 | Tie up at wharf in South Bar. |
| 2345 | Depart South Bar for Sydney. |

Time
(Local)

**August 28, 1987 - Julian Day 240**

0900 Arrive onboard Idle Oars II. Sunny morning, Sydney Harbour calm. Very light winds.
1000 Depart for site.
1100 Arrive at site. Conduct Bar Check.
1200 Deploy geophysical gear. Head toward SOL. Change layback from August 27, 1987 (boomer 10 m, streamer 15 m) to boomer 10 m, streamer 29 m.

1238 SOL 1N (PHN 1-1). FSP 1050. Heading 14 degrees.
1252 EOL 1N (PHN 1-1). LSP 1001.

1307 SOL 5S (PHN 5). FSP 1000. Heading 195 degrees.
1319 EOL 5S (PHN 5). LSP 1046.

1330 SOL 5N (PHN 5-1). FSP 1050.
1345 EOL 5N (PHN 5-1). LSP 1004.

1425 SOL 6S (PHN 6). FSP 1000. Heading 195 degrees.
1439 EOL 6S (PHN 6). LSP 1045.

1454 SOL 6N (PHN 6-1). FSP 1050. Heading 14 degrees. Seas picking up, becoming choppy and slow occasional white caps.
1510 EOL 6N (PHN 6-1). LSP 1006.

1517 SOL 7S (PHN 7). FSP 1000.
1540 EOL 7S (PHN 7). LSP 1046. Running perpendicular to seas. Boat rolling excessively. Will try running a tie line parallel to the seas.

1549 SOL 11W (PHN 11). FSP 1085. Heading 285 degrees.
1610 EOL 11W (PHN 11). LSP 1003.

1640 SOL 10E (PHN 10). FSP 1000. Heading 105 degrees.
1710 EOL 10E (PHN 10). LSP 1082. Winds picking up.

1720 SOL 12W (PHN 12). FSP 1085. Heading 285 degrees.
1742 EOL 12W (PHN 12). LSP 1000.

1750 Pull in gear and begin steaming toward South Bar.
1845 Arrive at wharf at South Bar. Secure gear. Return to Sydney.

**August 29, 1987 - Julian Day 241**

0845 Set up Trisponder base stations.
0900 Onboard boat. Winds light, seas <30 cm in Sydney Harbour.
0920 Depart for site.
1020 Arrive at western edge of site.
1030 Begin third Bar Check.

Time
(Local)

**August 29, 1987 - Julian Day 241 (continued)**

1059 Bar Check complete. Resultant velocity dialed into the DESO 20 - 1457 m/s. Bar Check conducted in 10 m of water with the target out 8.67 m. This is the average water depth at the site.

1110 Seas very calm at the site. Very light winds. No waves. Sunny and warm day. Deploy geopulse system. Boomer put out 10 m starboard side. The short (1 m) ministreamer is being used today. This streamer is out 20 on the port side.

1118 False start to line 9E.

1130 SOL 9E (PHN 9). FSP 1000. Heading 105 degrees. All previous lines run with water velocity set at 1400 m/s. This and all subsequent lines will be run with water velocity of 1457 m/s.

1155 EOL 9E (PHN 9). LSP 1075.

1206 SOL 8N (PHN 8). FSP 1050. Heading 15 degrees.

1220 EOL 8N (PHN 8). LSP 1000.

1229 SOL 8S (PHN 8-1). FSP 1000. Heading 195 degrees.

1243 EOL 8S (PHN 8-1). LSP 1050.

1254 SOL 9W (PHN 9-1). FSP 1075. Heading 285 degrees.

1310 EOL 9W (PHN 9-1). LSP 1000. Problems with paper (on DESO 20) slippage on this line. Power reduced to 105 Joules on geopulse power supply because of problem with EPC keeping up with firing rate.

1329 SOL 11E (PHN 11-1). FSP 1000. Heading 1000.

1404 EOL 11E (PHN 11-1). LSP 1179. Seas picking up, becoming choppy. Waves 1/2 m. NE wind blowing 10-15 knots.

1420 SOL 7.1S (PHN 7-1). FSP 1000. Heading 195 degrees.

1432 EOL 7.1S (PHN 7-1). LSP 1046. Wind 15 knots NE. Seas choppy.

1455 SOL 14N (PHN 14). FSP 1085. Heading 06 degrees.

1517 EOL 14N (PHN 14). LSP 1006.

1535 SOL 13S (PHN 13). FSP 1000. Heading 185 degrees.

1600 EOL 13S (PHN 13). LSP 1079. Seas still rough and getting rougher. Occasional white caps. Echosounder data displays heave in the order of 1/2 m. Winds 15-20 knots NE.

1632 SOL 4.2N (PHN 4-2). FSP 1050. Heading 15 degrees.

1647 EOL 4.2N (PHN 4-2). LSP 1000.

1650 Seas too rough to shoot any more data. Begin pulling in gear.

1655 Gear onboard. Leaving site. Steaming toward South Bar Government Wharf to demob boat.

1745 Tie up at wharf. Start demobing boat immediately.

2000 Finish demobilizing vessel. Van and truck loaded with gear. Head into Sydney.

Time
(Local)

**August 30, 1987 - Julian Day 242**

0930 Depart Sydney for Halifax.

# APPENDIX 2

# SURVEY SYSTEMS

## APPENDIX 2

## SURVEY SYSTEMS

A summary of the equipment employed in the Sydney geophysical survey is given below. Table 2-1 presents the configuration of the seismic, bathymetry and navigational systems.

### 2.1 Horizontal Control for Vessel

A Del Norte Trisponder, Mod 540 was employed as the primary positioning system.

Four, shore-based transponders and the computing software of Nortech Surveys provided highly accurate positions for the survey vessel while on line. Nortech's software in conjunction with the Hewlett Packard 9836 computer performed various functions:

a) record four range measurements

b) compute geographic position of the vessel

c) record ranges and positions at regular time or distance intervals (10 metre distance intervals for instance)

d) record digital water depth output from the echosounder at regular intervals

e) output event marks at regular time or distance intervals for marking of analogue profile records

f) provide line-steering guidance to the navigator via a monitor at the navigator's station and to the helmsman via a remote monitor.

Nortech's software employs least squares computation and Kalman Filtering techniques to optimize position fixing.

Nortech used the tape-recorded positioning data to produce track plots following the survey, at a working scale of 1:5000.

The Del Norte Trisponder is a microwave system operating at a frequency of approximately 9400 MHz. The system provides positional accuracy of +/- 1 metre typically. Two, 12 volt auto batteries provided 24 VDC to each of four transponders located along the shoreline near the survey area.

## 2.2 Horizontal Control Onshore

We had investigated the availability of control points along the shoreline prior to this project start-up by contacting the Sydney office of the Land Registration Information Service (LRIS). Information at that time indicated that there were sufficient control points in place to allow installation of the four transponders so as to provide good coverage of the survey area while meeting geometric constraints.

A reconnaissance survey was conducted during the first field day of this project to find these benchmarks. It was discovered that these sites had been modified, destroying or masking the original benchmarks. It was therefore necessary to survey-in alternate control points which provided unobscured line-of-site visability and appropriate geometry.

## 2.3 Precision Echosounder

In consideration of the fact that the study was concerned about subsidence of less than 3 metres maximum, grading to no displacement at the extremities of the subsidence profile, a minimum of 400 metres apart, it was necessary to employ a high resolution, precision echosounder. The echosounder selected has the ability to vary paper transport rate and stylus sweep range so that good horizontal and vertical resolution of seafloor features can be realized.

This project utilized the ATLAS DESO-20, a start-of-the-art survey sounder, for precise recording of seafloor profiles. This system offers the following features:

- Simultaneous, dual frequency operation: 210 kHz and 33 kHz. The low frequency output component is capable of penetrating soft surficial sediments and so acts as a very high resolution, shallow subbottom profiler and seabed classification system. The high frequency output component provides the highest resolution profile of the seafloor.
- digitization of water depth with LED display and output to navigation computer for permanent recording
- wide choice of vertical recording ranges permits choice of vertical scale to optimize resolution
- wide choice of paper transport speeds - adjustable in 10 steps from 12.0 to 0.015 mm/second permits selection of a horizontal scale to optimize resolution

- automatic annotation of recording parameters such as:
  - speed of sound in water (measured by bar check)
  - measuring range and phase
  - time and distance marks
- graphical precision at 210 kHz is +/- 0.12% of depth +/- 1.5 cm, using a narrow beam transducer (9 degrees).

We mounted the echosounder transducers on a gimballed over-the-side mount which compensated for modest vessel motion.

We calibrated the echosounder for draught of the transducers to be 55 cm and for speed of sound in sea water (by means of the hydrographic standard bar checking technique) to be 1457 m/s.

Compensation of echosounding measurements for tidal changes were made using data from the North Sydney permanent tidal gauge (Table 2-2).

The ATLAS DESO-20's precision and flexible choice of recording scales permitted selection of optimum recording parameters for the purpose of pre- and post-subsidence profile comparison.

## 2.4 Boomer Seismic Reflection System

We considered that some definition of surficial sediment thickness and buried bedrock surface would be beneficial in the baseline and subsequent surveys. This was necessary to define the pre-subsidence topography of the stable bedrock surface which would be unaffected by erosion.

The Ferranti O.R.E. Geopulse system was employed for the recording of seismic profiles. This system is comprised of the following components:

A) a catamaran-supported "Boomer" transducer which is towed behind the survey vessel

B) a high resolution, multi-hydrophone array also towed behind the vessel

C) a high voltage power supply on the survey vessel with five energy output levels between 105 and 455 joules

D) a multi-function signal processing unit, including:

- bottom-tracking, time-varied gain amplifier
- band pass filter
- magnetic tape interface simplifies tape recording
- fibre optic isolation of the receiver from power supply to eliminate ground interference.

We recorded the boomer profiles on both EPC 3200 and EPC 1600 graphic recorders and on a Hewlett Packard 9638, 8-track tape recorder.

The geophysical records acquired with this system during the survey are of good to poor quality; deteriorating with sea state at the site. Some of the records suffer from a bottom-simulating reflector which occurs approximately 2.5 ms below the seafloor. The source of this energy is uncertain. Most records have a broad bubble pulse, especially in areas of bedrock outcrop but also in areas of sediment cover.

Significant penetration, up to 20 msec (~ 25 m*) has been achieved on some of the data in areas of bedrock.

In areas of suspected channelling, up to 20 msec (15 m**) of sediment appear to be present.

* Calculated on the basis of a bedrock velocity of 2500 m/s.

** Calculated on the basis of a sediment velocity of 1500 m/s.

**TABLE 2-1 CONFIGURATION OF SURVEY EQUIPMENT**

| | | | |
|---|---|---|---|
| Navigation Antenna to Boomer | 18.5 m | | (Starboard) |
| Navigation Antenna to Echosounder | 2.5 m | | (Port) |
| Navigation Antenna to Centre of Receiver Array | 28.5 m | (Day 240 & 241) | (Port) |
| | 23.5 m | (Day 239) | (Port) |
| Navigation Antenna to Centre Line | 0 m | | |
| Navigation Antenna to Side of Vessel | 1.9 m | | |
| Navigation Antenna to Stern of Vessel | 8.5 m | | |

OBSERVED TIDES (cm. above old chart datum).

PROVISIONAL DATA — DONNEES PRELIMINAIRES

HOURLY WATER LEVELS AND DAILY MEANS — DONNEES HORAIRES ET MOYENNES JOURNALIERES DU NIVEAU DE L'EAU

STATION 2/4613/06015 (00612)

DATA PREPARED BY — DONNEES PREPAREES PAR LE
MARINE ENVIRONMENTAL DATA SEVICE (MEDS) — NORTH SYDNEY N S — SERVICE DES DONNEES SUR LE MILIEU MARIN (SDMM)

AUGUST 1987 AOUT

HOURLY DATA (CM) DONNEES HORAIRES

| | 0100 | 0200 | 0300 | 0400 | 0500 | 0600 | 0700 | 0800 | 0900 | 1000 | 1100 | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 | 2200 | 2300 | 2400 | MEAN (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 144 | 124 | 117 | 91 | 65 | 68 | 86 | 89 | 107 | 131 | 130 | 149 | 135 | 132 | 118 | 100 | 88 | 80 | 76 | 90 | 98 | 115 | 135 | 134 | 1.09 |
| 2 | 148 | 132 | 120 | 105 | 86 | 74 | 70 | 77 | 93 | 102 | 126 | 125 | 134 | 131 | 122 | 110 | 96 | 89 | 74 | 89 | 89 | 109 | 122 | 135 | 1.07 |
| 3 | 140 | 140 | 133 | 118 | 97 | 91 | 62 | 75 | 68 | 89 | 96 | 111 | 119 | 126 | 124 | 115 | 105 | 96 | 87 | 83 | 91 | 100 | 113 | 130 | 1.05 |
| 4 | 145 | 145 | 141 | 133 | 120 | 111 | 85 | 85 | 70 | 85 | 83 | 103 | 113 | 127 | 128 | 134 | 123 | 122 | 104 | 98 | 97 | 100 | 110 | 117 | 1.11 |
| 5 | 139 | 139 | 152 | 152 | 139 | 134 | 108 | 101 | 77 | 80 | 74 | 85 | 95 | 109 | 120 | 133 | 129 | 126 | 112 | 102 | 93 | 90 | 97 | 96 | 1.12 |
| 6 | 114 | 125 | 137 | 152 | 145 | 147 | 122 | 111 | 93 | 75 | 62 | 63 | 72 | 85 | 98 | 116 | 124 | 131 | 126 | 115 | 107 | 84 | 85 | 87 | 1.07 |
| 7 | 95 | 108 | 125 | 135 | 153 | 148 | 148 | 121 | 109 | 79 | 63 | 51 | 49 | 52 | 73 | 91 | 112 | 126 | 127 | 123 | 111 | 94 | 85 | 72 | 1.02 |
| 8 | 75 | 84 | 106 | 119 | 147 | 155 | 159 | 153 | 128 | 109 | 76 | 54 | 40 | 39 | 51 | 67 | 92 | 117 | 129 | 139 | 124 | 118 | 92 | 83 | 1.02 |
| 9 | 68 | 71 | 86 | 101 | 129 | 148 | 166 | 169 | 163 | 135 | 103 | 74 | 53 | 32 | 42 | 50 | 77 | 99 | 128 | 138 | 149 | 133 | 116 | 98 | 1.06 |
| 10 | 67 | 72 | 56 | 69 | 96 | 133 | 150 | 173 | 167 | 164 | 134 | 100 | 76 | 40 | 37 | 38 | 58 | 76 | 110 | 129 | 156 | 141 | 144 | 105 | 1.05 |
| 11 | 92 | 65 | 59 | 63 | 92 | 104 | 136 | 151 | 178 | 173 | 164 | 133 | 109 | 73 | 55 | 42 | 57 | 69 | 102 | 125 | 154 | 157 | 162 | 136 | 1.11 |
| 12 | 117 | 85 | 71 | 54 | 68 | 87 | 115 | 139 | 163 | 172 | 163 | 154 | 121 | 95 | 64 | 49 | 46 | 58 | 80 | 99 | 128 | 143 | 154 | 137 | 1.07 |
| 13 | 121 | 90 | 74 | 53 | 51 | 62 | 80 | 104 | 127 | 147 | 157 | 148 | 131 | 104 | 77 | 56 | 47 | 49 | 64 | 81 | 105 | 123 | 141 | 140 | .97 |
| 14 | 128 | 109 | 79 | 62 | 54 | 50 | 60 | 95 | 104 | 125 | 138 | 145 | 132 | 122 | 93 | 80 | 62 | 51 | 63 | 75 | 94 | 115 | 131 | 140 | .96 |
| 15 | 135 | 121 | 104 | 74 | 71 | 46 | 66 | 65 | 94 | 104 | 123 | 134 | 140 | 128 | 121 | 99 | 89 | 74 | 66 | 87 | 91 | 113 | 131 | 137 | 1.01 |
| 16 | 145 | 132 | 124 | 97 | 87 | 67 | 63 | 67 | 76 | 92 | 101 | 116 | 124 | 124 | 124 | 111 | 98 | 91 | 81 | 89 | 94 | 105 | 123 | 133 | 1.03 |
| 17 | 137 | 147 | 132 | 127 | 102 | 93 | 76 | 71 | 81 | 82 | 98 | 103 | 114 | 119 | 125 | 117 | 115 | 98 | 101 | 86 | 95 | 92 | 112 | 118 | 1.06 |
| 18 | 133 | 135 | 140 | 126 | 120 | 103 | 91 | 85 | 72 | 83 | 74 | 94 | 92 | 108 | 113 | 123 | 117 | 113 | 106 | 100 | 95 | 99 | 107 | 108 | 1.06 |
| 19 | 129 | 120 | 140 | 133 | 131 | 124 | 103 | 101 | 77 | 80 | 78 | 76 | 94 | 89 | 111 | 112 | 121 | 123 | 114 | 113 | 102 | 96 | 105 | 104 | 1.07 |
| 20 | 113 | 128 | 128 | 145 | 134 | 138 | 125 | 113 | 95 | 85 | 74 | 70 | 73 | 76 | 90 | 100 | 115 | 115 | 116 | 109 | 105 | 94 | 94 | 93 | 1.05 |
| 21 | 97 | 109 | 124 | 136 | 143 | 150 | 142 | 135 | 114 | 102 | 80 | 73 | 72 | 72 | 83 | 98 | 112 | 118 | 124 | 121 | 116 | 100 | 94 | 82 | 1.08 |
| 22 | 89 | 84 | 110 | 110 | 134 | 144 | 144 | 136 | 122 | 102 | 88 | 72 | 61 | 66 | 65 | 89 | 92 | 119 | 122 | 126 | 121 | 109 | 100 | 87 | 1.04 |
| 23 | 83 | 79 | 93 | 107 | 120 | 139 | 147 | 152 | 143 | 130 | 107 | 97 | 68 | 82 | 64 | 93 | 97 | 121 | 130 | 137 | 132 | 134 | 107 | 96 | 1.11 |
| 24 | 79 | 72 | 95 | 92 | 112 | 130 | 144 | 148 | 155 | 131 | 120 | 93 | 76 | 65 | 65 | 74 | 94 | 106 | 130 | 140 | 144 | 138 | 122 | 104 | 1.09 |
| 25 | 65 | 79 | 74 | 90 | 99 | 124 | 138 | 155 | 152 | 149 | 127 | 106 | 82 | 65 | 53 | 67 | 75 | 98 | 109 | 132 | 135 | 137 | 130 | 104 | 1.07 |
| 26 | 93 | 77 | 70 | 77 | 87 | 113 | 126 | 149 | 163 | 154 | 143 | 120 | 100 | 75 | 64 | 60 | 74 | 84 | 111 | 123 | 145 | 140 | 138 | 119 | 1.09 |
| 27 | 100 | 79 | 71 | 81 | 77 | 94 | 115 | 137 | 153 | 156 | 148 | 135 | 111 | 87 | 72 | 63 | 69 | 82 | 101 | 119 | 135 | 145 | 141 | 128 | 1.07 |
| 28 | 109 | 86 | 70 | 55 | 62 | 75 | 93 | 116 | 133 | 145 | 141 | 133 | 114 | 92 | 74 | 65 | 61 | 70 | 87 | 102 | 128 | 136 | 145 | 131 | 1.01 |
| 29 | 115 | 97 | 72 | 58 | 54 | 60 | 82 | 90 | 122 | 129 | 137 | 131 | 129 | 96 | 91 | 66 | 69 | 62 | 83 | 97 | 113 | 139 | 140 | 143 | .99 |
| 30 | 126 | 111 | 91 | 76 | 54 | 69 | 62 | 92 | 98 | 125 | 129 | 136 | 134 | 115 | 99 | 83 | 76 | 67 | 80 | 89 | 103 | 122 | 135 | 138 | 1.00 |
| 31 | 130 | 125 | 98 | 77 | 72 | 50 | 67 | 63 | 95 | 96 | 116 | 118 | 130 | 116 | 112 | 93 | 85 | 73 | 75 | 83 | 95 | 111 | 128 | 130 | .97 |

INSTANTANEOUS LEVELS — MONTHLY MEAN 1.050 M — MOYENNE MENSUELLE — MOYENNE

| | DAY | TIME | HEIGHT | | | TIME ZONE: AST | FUSEAU HORAIRE |
|---|---|---|---|---|---|---|---|
| HIGH | 11 | 0000 | 1.78 M | HAUT | REFERENCE DATUM | | NIVEAU DE REFERENCE |
| LOW | 9 | 1415 | .31 M | BAS | HOURLY HEIGHTS - CHART DATUM | | DONNEES HORAIRES - ZERO DES CARTES |
| | JOUR | HEURE | HAUTEUR | | INSTANTANEOUS LEVELS - CHART DATUM | | NIVEAUX INSTANT. - ZERO DES CARTES |
| | NIVEAUX INSTANTANES | | | | MEANS - CHART DATUM | | MOYENNES - ZERO DES CARTES |

DATE AND TIME OF RUN 04/01/88 19.06.01. DATE ET TEMPS D'IMPRESSION

OBSERVED TIDES – (cm. above old chart datum)

TABLE 2-2

# APPENDIX 3

# PERSONNEL

## APPENDIX 3

## PERSONNEL

McGregor GeoScience Limited acted as prime contractor for the survey. Direct contractal obligations included overall quality control during the survey, collection of geophysical and bathymetric data and the interpretation of the collected data.

The survey vessel was the Idle Oars II owned by Stewart Squires of Big Bras d'Or, Cape Breton, Nova Scotia.

Nortech Atlantic Ltd. provided the navigation equipment and personnel.

### Personnel

**McGregor GeoScience Limited**

| | |
|---|---|
| Project Manager | John Stewart |
| Marine Geologist | Tony LaPierre |
| Geophysical Engineer | Steve Fehr |

**Nortech Atlantic Limited**

| | |
|---|---|
| Navigator | Gary Palmatary |

**Idle Oars II**

| | |
|---|---|
| Skipper | Stewart Squires |
| Skipper | Jim Squires |
| Deckhand | Trevor Squires |

# APPENDIX 4

# NAVIGATION REPORT

PHALEN SUBSIDENCE STUDY

ENERGY MINES AND RESOURCES CANADA

CAPE BRETON COAL REASEARCH LABORATORY

AUGUST 1987

# NAVIGATION REPORT

PREPARED BY

NORTECH ATLANTIC Ltd
133 HAMPTON GREEN
DARTMOUTH NOVA SCOTIA

## 1 INTRODUCTION

Nortech Atlantic provided navigation services to McGregor Geoscience of Halifax, in order for them to conduct a bathymetric and shallow sub-surface survey in the waters off New Waterford Cape Breton Island, over top of DEVCO's Phalen Colliery. The survey was conducted for Energy Mines and Resources, Cape Breton Coal Research Laboratory.

This report covers the establishment of shore stations, calibration of the navigation system, the survey itself and the mapping of results.

## 2 NAVIGATION SYSTEM

The navigation system used was Del Nortes microwave Trisponder. This is a range-range pulse type system, with an accuracy of about 3-4 metres on each range, when calibrated. Four shore stations were set up to provide accurate coverage over the survey area.

## 3 SHORE STATIONS

The coordinate system used by DEVCO was a cartesian grid, scaled in metres with the origin near New Waterford and has a small rotation with respect to the UTM grid. The sounding line end coordinates were provided in the DEVCO grid, consequently it was decided to conduct the survey completely within this grid.

A reconnaissance of the shore area was conducted prior to the survey to determine the best location for the shore stations and which control was available to establish these shore stations.

The survey control used was that established by LRIS to which DEVCO had the coordinates for in the DEVCO grid. There was only one LRIS monument where the Trisponder could be set up. The remaining 3 trisponder shore stations had to be surveyed in from LRIS control. See appendix A for a description of each point.

In establishing the locations of the shore points, security was the major factor after line of sight to the survey area. This was because only one station could be manned. Fortunately two points could be established on DEVCO property and the third on crown land near Low Point light house.

The following table lists the station name. the code of the trisponder unit and the coordinates of the station.

TABLE OF SHORE STATION DATA

| STATION | REMOTE CODE | Y (m) | X (m) |
|---|---|---|---|
| #26 colliery | 72 | -3300.1 | 7952.1 |
| Lingan Airshaft | 76 | -8.6 | 2314.6 |
| 1614 LRIS | 82 | 464.2 | 207.0 |
| Light House | 94 | 1350.9 | -3282.6 |

## 4 TRISPONDER CALIBRATION

The Trisponder was calibrated over water near the South Bar wharf where the survey boat tied up. Two points were established and the distance between them was measured with an EDM and found to be 1255.11 metres. The same distance was measured by the Trisponder equipment and compared to the correct distance. The following table depicts those results.

| Master Code | Remote Code | Correct Distance | Observed Distance | Correction |
|---|---|---|---|---|
| 76 | 72 | 1255.11 | 2121.1 | -865.99 |
| 76 | 76 | 1255.11 | 2109.9 | -854.79 |
| 76 | 82 | 1255.11 | 2092.4 | -837.32 |
| 76 | 94 | 1255.11 | 2097.95 | -842.84 |
| 78 | 72 | 1255.11 | 2102.0 | -846.89 |
| 78 | 76 | 1255.11 | 2092.75 | -837.64 |
| 78 | 82 | 1255.11 | 2076.4 | -821.29 |
| 78 | 94 | 1255.11 | 2078.25 | -823.14 |

The correction was entered directly into the Trisponder DMU this caused the ranges to be corrected before the computer received them.

## 5 SURVEY

The Trisponder measured slope ranges from the ship to each of the 4 shore stations and sent them to the HP9836 computer. In addition to providing normal navigation functions the computer was also interfaced to the sounder digitizer. The depths were read and stored every 3 seconds. The computer also output the velocity, however the sounder, an Atlas Deso 20, cannot accept a digital input but requires a unique analogue input which a computer cannot produce. Consequently the paper speed of the sounder was not corrected to match the boad's speed. A digital to analogue converter would have had to be built.

The standard error of the fix coordinates was about 4 to 6 metres on the main site. West Phalen. The geometry was poor on the East Phalen site and in many instances only 2 or 3 ranges were observed. The 2 lines surveyed on East Phalen had a standard error between 4 and 20 metres.

Both helmsmen had difficulity keeping the boat on track the first day: they over corrected thus causing a weavy line. Considerable improvement was noted on the following days.

The following table lists the line end coordinates. Most of the lines were surveyed twice. once in each direction. The second time a line was surveyed a '.1' was appended to tne end of the line name.

Table of Line End Coordinates

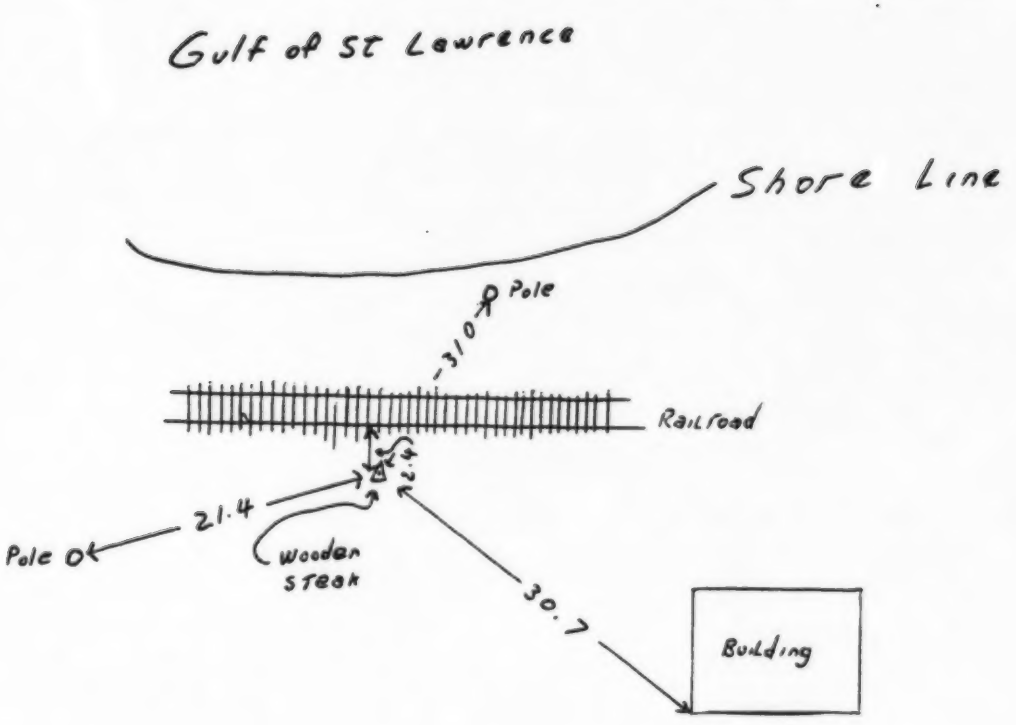
| Line name | end coordinates Y | X | end coordinates Y | X |
|---|---|---|---|---|
| W Phalen 1 | 2100 | 1600 | 900 | 1300 |
| W Phalen 2 | 2000 | 1800 | 900 | 1500 |
| W Phalen 3 | 2000 | 2000 | 900 | 1700 |
| W Phalen 4 | 2000 | 2200 | 800 | 1875 |
| W Phalen 5 | 1900 | 2375 | 800 | 2075 |
| W Phalen 6 | 1800 | 2540 | 700 | 2240 |
| W Phalen 7 | 1800 | 2740 | 700 | 2440 |
| W Phalen 8 | 1800 | 2940 | 600 | 2620 |
| W Phalen 9 | 1280 | 1100 | 800 | 2920 |
| W Phalen 10 | 1500 | 1100 | 970 | 3100 |
| W Phalen 11 | 1700 | 1175 | 1175 | 3150 |
| W Phalen 12 | 1940 | 1150 | 1355 | 3200 |
| W Phalen 13 | 2000 | 5000 | 0 | 4800 |
| W Phalen 14 | 2000 | 4200 | 0 | 4000 |

## 6 MAPPING

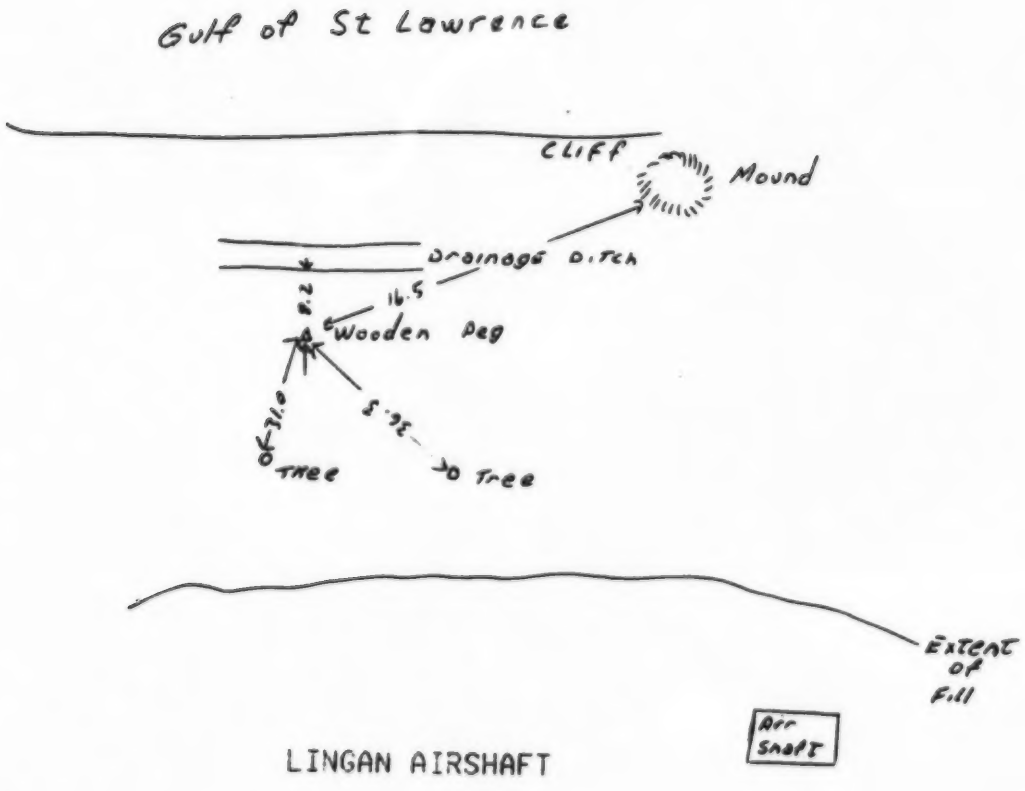
Since most of the lines were surveyed twice two maps were produced. each having a particular line plotted in only one direction. This avoided the clutter that would have resulted if all the data was plotted on one sheet. The maps were plotted at a scale of 1:5000.

# APPENDIX A

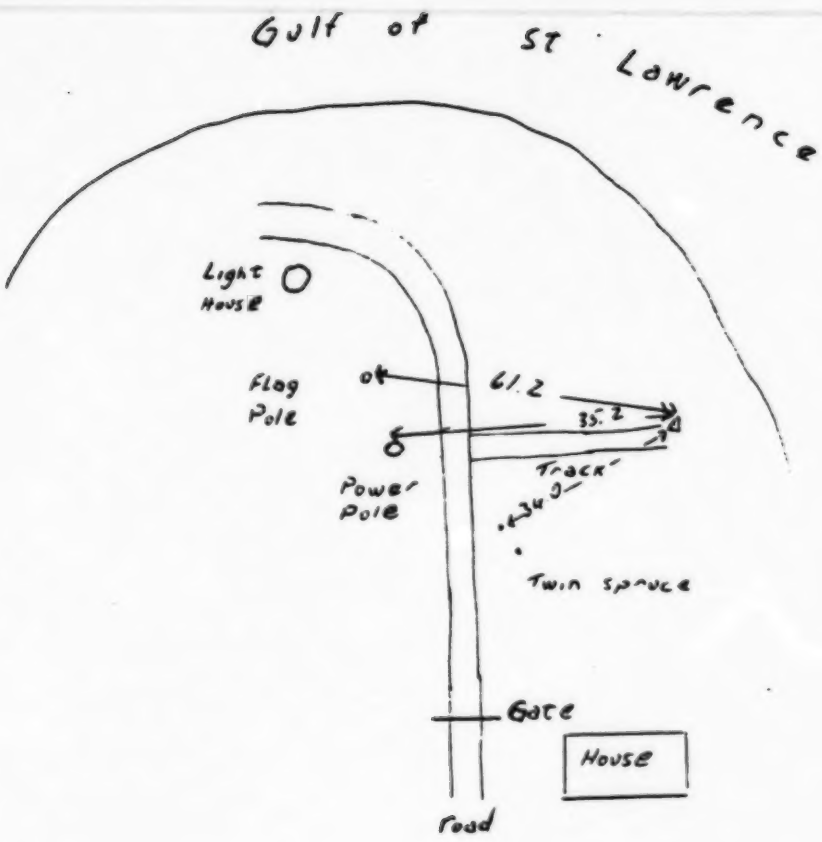
## SHORE STATION DESCRIPTIONS




#25 COLLIERY




LINGAN AIRSHAFT




LOW POINT LIGHT HOUSE

# APPENDIX B

# EQUIPMENT

Transponder

4 Remote TR's
2 Master TR's
1 562 DDUM
10 Lead acid batteries
Antennas and cables

Computer Equipment

1 HP9836 Computer
1 HP2671G Printer
Interfaces and cables

Survey Gear

1 HP3800 EDM
1 Sokisha transit
Chain, steaks, tripods etc.

Power Equipment

1 2200 watt Generator
1 24 VDC power supply
Power bars, cables etc.

# APPENDIX 5

# DATA INVENTORY AND QUALITY SUMMARY

## APPENDIX 5

## DATA INVENTORY AND QUALITY SUMMARY

| Track Plot Line # | Record # | Boomer | Echosounder | Quality | Heave |
|---|---|---|---|---|---|
| Line PHN 1 | 1S | X | | G | None |
| | | | X | E | |
| PHN 1-1 | 1N | X | | G | <10 cm |
| | | | X | VG | |
| PHN 2 | 2S | X | | G | None |
| | | | X | E | |
| PHN 2-1 | 2.1N | X | | G | <10 cm |
| | | | X | VG | |
| PHN 3 | 3S | X | | G | None |
| | | | X | E | |
| PHN 3-1 | 3N | X | | G | 10-15 |
| | | | X | G | |
| PHN 4 | 4S | X | | F | <10 cm |
| | | | X | VG | |
| PHN 4-2 | 4.2N | X | | P | 15-25 cm |
| | | | X | F | |
| PHN 5 | 5S | X | | G | None |
| | | | X | E | |
| PHN 5-1 | 5N | X | | G | 10-15 cm |
| | | | X | G | |
| PHN 6 | 6S | X | | G | 10-20 cm |
| | | | X | G | |
| PHN 6-1 | 6N | X | | G | 10-15 |
| | | | X | G | |
| PHN 7 | 7S | X | | P | 30-50 cm |
| | | | X | P | |
| PHN 7-1 | 7.1S | X | | F | 10-15 cm |
| | | | X | G | |
| PHN 8 | 8N | X | | P | <10 cm |
| | | | X | VG | |

| Track Plot Line # | Record # | Boomer | Echosounder | Quality | Heave |
|---|---|---|---|---|---|
| Line PHN 8-1 | 8S | X | | P | None |
| | | | X | E | |
| PHN 9 | 9E | X | | P | None |
| | | | X | E | |
| PHN 9-1 | 9W | X | | P | 15-25 cm |
| | | | X | F | |
| PHN 10 | 10E | X | | G | 10 cm |
| | | | X | G | |
| PHN 11 | 11W | X | | P | 5-15 cm |
| | | | X | G | |
| PHN 11-1 | 11E | X | | G | 15-25 cm |
| | | | X | F | |
| PHN 12 | 12W | X | | G | None |
| | | | X | VG | |
| PHN 13 | 13S | X | | P | 20-30 cm |
| | | | X | P | |
| PHN 14 | 14N | X | | P | 15-25 cm |
| | | | X | P | |

# PHALEN

## SUBSIDENCE STUDY

## CAPE BRETON N.S.

ENERGY MINES and RESOURCES, CANADA
CAPE BRETON COAL RESEARCH LABORATORY

TRACK PLOT of EVENT MARKS

PHALEN
SUBSIDENCE STUDY
CAPE BRETON N.S.
ENERGY MINES and RESOURCES, CANADA
CAPE BRETON COAL RESEARCH LABORATORY
TRACK PLOT of EVENT MARKS




SCALE 1:5000

| | |
|---|---|
| Projection: DEVCO GRID | Positioning system: Microwave Trisponder |
| Contractor: MCGREGOR GEOSCIENCE | Ship: IDLE OARS II |
| Navigation: NORTECH ATLANTIC | Date: AUG 87 |

**ENCLOSURE 1**

# PHALEN

## SUBSIDENCE STUDY
## CAPE BRETON N.S.

ENERGY MINES and RESOURCES, CANADA
CAPE BRETON COAL RESEARCH LABORATORY

TRACK PLOT of EVENT MARKS

# PHALEN

## SUBSIDENCE STUDY
## CAPE BRETON N.S.

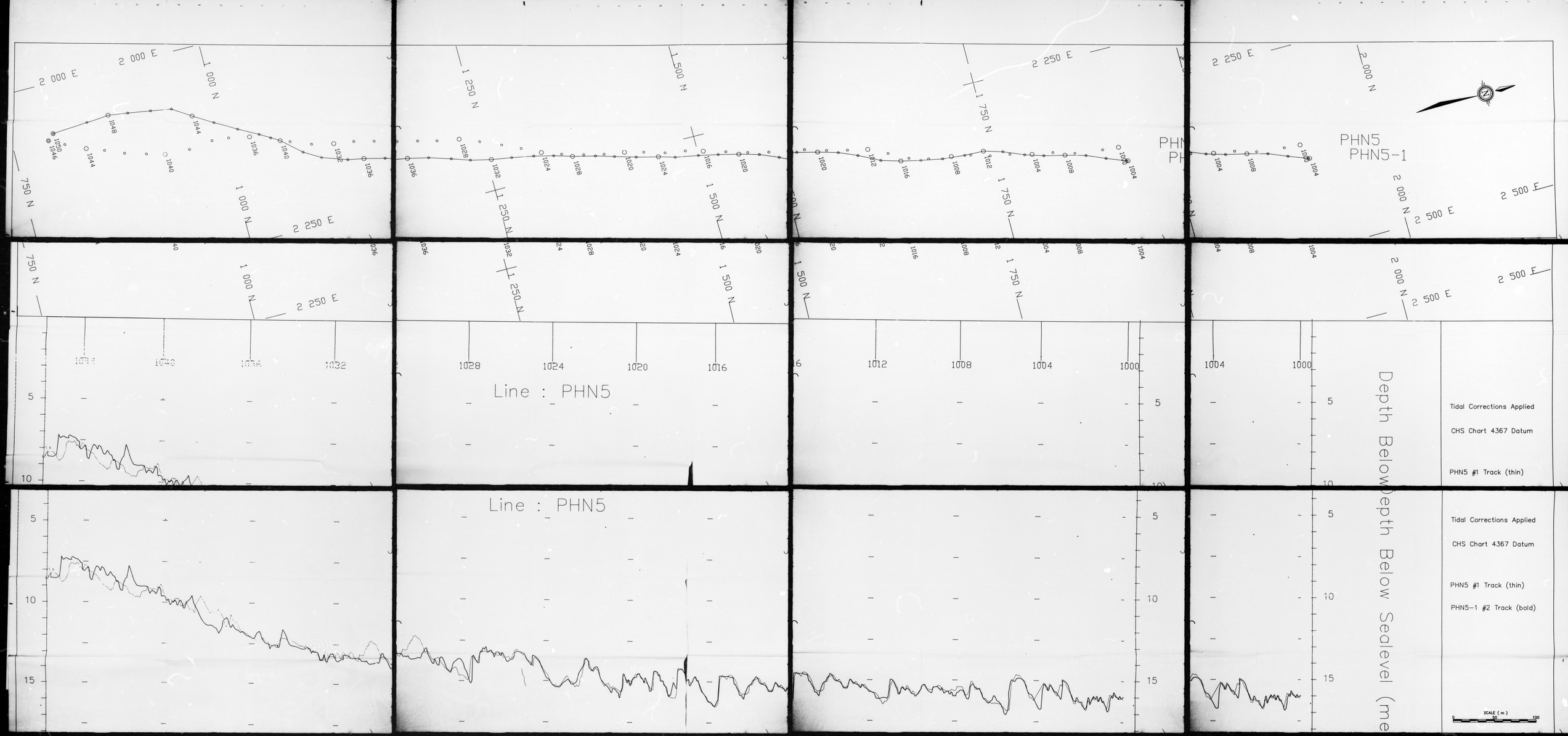
ENERGY MINES and RESOURCES, CANADA
CAPE BRETON COAL RESEARCH LABORATORY

TRACK PLOT of EVENT MARKS


SCALE 1:5000

| | |
|---|---|
| Projection: DEVCO GRID | Positioning system: Microwave Trisponder |
| Contractor: MCGREGOR GEOSCIENCE | Ship: IDLE OARS II |
| Navigation: NORTECH ATLANTIC | Date: AUG 87 |

ENCLOSURE 2


2 000 E
1 000 N
750 N
2 250 E
1 250 N
1 500 N
1 750 N
2 000 N
2 500 E
PHN5
PHN5-1
Line : PHN5
Line PHN5-1
Depth Below Sealevel (metres)
Tidal Corrections Applied
CHS Chart 4367 Datum
PHN5 #1 Track (thin)
PHN5-1 #2 Track (bold)
SCALE ( m )
0 50 100
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
SEAFLOOR SUBSIDENCE SURVEY
LINES PHN5/PHN5-1 PLAN
AND BATHYMETRIC PROFILES
Enclosure: 3
Date: MAR/88
Project: 87-24
Scale: 1:1000
Geologist: TONY LAPIERRE
Projection: DEVCO GRID UTM MODIFIED (CM: -60°05')
Prepared by: McGregor GeoScience Ltd.
1959 Upper Water St.
Halifax, Nova Scotia